THE UNIVERSITY OF ALBERTA

HEARING IN THE BEGINNING READER: A LONGITUDINAL STUDY

by

© EMILY GOETZ

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR

THE DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

EDMONTON, ALBERTA

SPRING, 1972

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled Hearing in the Beginning Reader: A Longitudinal Study submitted by Emily Goetz in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

Abstract

The primary purpose of this study was to examine, through a longitudinal design, the extent to which hearing skills improve in children during the half year before and the half year after they begin school and to compare these with data from cross-sectional studies. A secondary purpose was to relate hearing scores to beginning reading scores. Forty-nine children were selected at random and measured four times over one year for auditory acuity, auditory discrimination, auditory memory, pitch discrimination, and intelligence. At the last time of measurement, two reading instruments were administered; at this same time the children were given ear, nose, and throat examinations. At Time 4 a group of 20 children was chosen at random from one elementary school and given acuity tests as a check on possible practice effect from using the audiometer.

Analysis of variance indicated significant change over time for most auditory variables. Results indicate that a significant practice effect was probably operating since the change in most variables was significant between Time 1 and at least one of the other measuring times. This suggested that educators should be suspicious of auditory scores from a child who has not been previously tested. Correlations between hearing and reading were sparse. Pitch discrimination and auditory memory scores

correlated with the single consonant subtest of the phonics (reading) test; auditory memory also correlated significantly with the comprehension subtest of the second reading measure. A recommendation was made that the validity of auditory discrimination and memory instruments in education be examined against prevailing descriptions and theories of auditory perceptual processes.

TABLE OF CONTENTS

HEARING IN THE BEGINNING READER:

A LONGITUDINAL STUDY

Chapter One

Introduction

Variables from the area of hearing have increasingly become the target for educational researchers since the 1940's and 1950's. Studies by such researchers as Kennedy (1942) and Reynolds (1953) tended to approach hearing globally, and commonly included many different measures of hearing acuity, auditory discrimination, and auditory memory. Generally, hearing studies undertaken from 1940 to 1960 were related to school performance, and usually to reading.

The focus of auditory research in the last ten years has been less broad. Studies during the 1960's have investigated one or two hearing variables rather than many, and have generally used one instrument to measure each variable. These studies have typically represented attempts to relate reading to a single auditory trait: auditory discrimination or auditory memory. Rather than studying hearing acuity as a possible correlate of reading most experimenters simply used acuity tests to screen out children with hearing loss.

Because educators view the child's first school year as a critical one in terms of later school success (Rupp,

1969) the early school years, as they relate to the classroom setting, have often been a focus for auditory research. An examination of studies since the 1940's, however, would seem to indicate that a number of questions about hearing and reading in the beginning school years have not been answered. For example, as the child enters first grade, what happens to his hearing skills? How do they grow? Is there equal growth in skills? Does discrimination grow at the same rate as memory over time? Are there spurts in this growth over time? What happens to hearing skills when the child enters grade one? And is there indication that we should explore the degree to which auditory development can be accelerated just before or just after the child enters school?

It is the primary purpose of this study to investigate the extent to which hearing skills grow <u>during the time just before and just after children begin school</u>. As hearing skills have often been studied as they relate to beginning reading abilities, it is the secondary concern of this research to describe the relationship between hearing skills and some of the child's beginning reading skills. In addition, the study will be related to a description of auditory perception skills, though there has been little such application to educational problems (Witkin, 1969).

Background

The idea for this research came from a study by Helen Kennedy (1942) who investigated the relationship between hearing and reading and raised the possibility that at least certain aspects of hearing might be developmental. Kennedy gave audiometric, auditory discrimination, and reading tests to 433 University of Chicago Laboratory School students chosen from grades one, three, five, seven, and ten.

Kennedy's findings showed that the hearing scores of eight-year-olds were significantly higher than those of six-year-olds. Of the eighteen children with lowest acuity in her sample, only three were in the upper quartile in reading. They were in grade three, the others in grades one and two. Kennedy did not administer auditory discrimination tests to children below grade five, but did speculate about the importance of acuity as a correlate of learning to read.

Limitations to Kennedy's study include the selective nature of her sample (the median I.Q. was 125 according to school records) and the cross-sectional design of her research. She felt that a longitudinal approach would have provided means for inspecting hearing growth, as it relates to reading, more closely than she was able to do. In other words, rather than basing conclusions about growth on observations of children of different ages at one point

in time, Kennedy suggested observing one group over a period of time, tracing the growth of their hearing skills as related to their reading performance.

Since the Kennedy study, several researchers have investigated the growth characteristics of hearing acuity in children (Eagles, 1961; Frisina, 1963; Mykelbust, 1963; Price and Falck, 1963; and Siegenthaler, 1954). Their studies, like Kennedy's, have tended to approach auditory questions through a cross-sectional design. Most of them have included more than one hearing variable and measures of various reading skills. These studies generally include other auditory variables such as discrimination.

Dykstra (1966) categorized auditory research concerned with discrimination into three categories which may be generalized for use in studies of other hearing variables as these relate to reading. Dykstra's three groups are: those which compare good with poor readers; correlational studies which involve simultaneous testing of relationships between auditory and reading variables; and predictive studies, or those which explore relationships between auditory variables at the beginning of grade one and later reading achievement. The first group has yielded data that show auditory skills (such as discrimination) to be strong correlates of reading achievement when good and poor readers are compared. Data from the second group of studies--based on less selective samples, for example random samples--tend to be inconclusive. The third, or

predictive group of studies, typically has yielded small positive relationships between hearing and reading with correlation coefficients ranging from .2 to .4.

A few longitudinal studies have been conducted to explore growth traits of auditory discrimination and reading over grades one and two (Thompson, 1963; Poling, 1968). These studies have identified both auditory discrimination for speech and intelligence as positive correlates of success in primary reading. Thompson also showed that auditory discrimination scores increased during grade one and that it was not unusual for children entering grade one to have low auditory discrimination scores (p.376). Correspondingly, Poling indicated that children who enter grade one with excellent discrimination skills tend to become superior readers and to remain superior throughout grade two.

Research on auditory skills, then, has tended to be cross-sectional in nature, has pointed to possible growth characteristics of hearing skills, and has been typically concerned, in the early grades, with examining relationships between hearing and reading.

Since much of our information about auditory growth has come from cross-sectional research, we must consider that generalizations about growth or development rest largely upon the assumption that each age group has the same traits. In other words,

> . . . . because cross sectional data includes a different group of subjects at each age or grade level, there is a <u>cohort difference</u> involved. The population of students from which one sample is drawn may be systematically different from the population from which a second sample is drawn (Hilton and Patrick, 1970, pp. 16-17).

Hilton and Patrick describe two kinds of data that do not involve group differences: matched and unmatched longitudinal data. Unmatched data involve measurement of all students tested each time whether or not they were in the original sample. By contrast, " . . . matched longitudinal data involve only that core of students who have data for all test administrations (p. 15)." Though there is an obvious selectivity bias with matched data, they would seem preferable to the researcher who is interested in generalizing to an actual school population. The matched longitudinal design also makes it possible to employ statistical correlation which is useful to the researcher who wants to explore relationships over time. Hilton and Patrick encourage random sampling rather than sampling from intact groups as a sounder basis upon which to generalize.

Thus for the researcher who is interested in exploring relationships between growth traits of given variables over time, matched longitudinal data and random sampling seem desirable.

Conceptual Foundations of the Study

Auditory perception. As stated previously, there has been very little attempt to relate auditory variables within educational research to any given model of auditory perception (Witkin, 1969). More clearly the development of auditory instruments commonly used in educational research has not been based on theoretical perceptual models. Instead, instruments have been framed to represent and test certain skills deemed important to school success, usually to reading. Testing the child's auditory perceptual skills has not been the problem; testing the child's auditory discrimination, acuity, or auditory memory has been. Even the fairly recently developed "psycholinguistic" tests, which purportedly assess auditory perceptual abilities, tend to be used by hospital diagnosticians rather than by educators, with the possible exception of the school psychologist and reading specialist when they test an allegedly brain-damaged child.

The data obtained from studies such as those summarized in Chapter Two are based upon a series of instruments of high practical utility. These auditory instruments have not been systematically related to or developed from any one concept of auditory perception. This produces two inherent dangers. First, without relating auditory instruments to an auditory theory, the researcher can be unaware of how those skills he chooses to test fit into a

perceptual model of an auditory mode which will inevitably include _other_ skills. Therefore, he may not have an accurate perspective on his research as it relates to a theory of auditory perception. Second, developing an instrument outside a model which purportedly separates auditory mode into separate skills increases the probability of not recognizing that basic skills may be confounded within the same instrument, a criticism that has been applied to Wepman's discrimination instrument (Witkin, 1969). This becomes an especially critical factor where remediation of a skill is concerned (based on a low score on the Wepman test, for example), as it is difficult to improve one skill when what one is actually teaching without realizing it, is two skills simultaneously.

This researcher has chosen Witkin's description of auditory perception (1969) for its applicability to educational settings, in spite of the author's caution that "There is no generally accepted model of auditory perception" (Witkin, 1969, p. 67). Witkin first defines acuity as an overriding and primary auditory ability:

> Regarding sensory perception in listening, the primary concern is with the hearing acuity of the individual and his ability to receive the sensation of sound without distortion. In cognition, the concern is with the ability to comprehend and retain spoken language and to perform such tasks as recognizing main ideas, analyzing, recalling details, and associating ideas. Auditory perception involves focus, attention, tracking, sorting, scanning, comparing, retrieving, and sequencing of spoken

> messages at the moment of utterance (Witkin, 1969, p. 54).

Witkin then categorizes auditory perceptual skills into five groups:

1. Attention is defined as a kind of "auditory figure-ground perceptual task"(p. 63), whereby the child learns to focus on one message in the presence of other potentially distracting ones.

2. Tracking, or compressed speech, has to do with how fast an individual can process information presented orally.

3. Auditory discrimination, or " ... the capacity to distinguish between phonemes ..."(p. 62), is described as an acquired skill in learning the sound structure of one's native language and as essential for the acquisition of language and for learning to read.

4. Auditory memory span, as described by Witkin, is related to auditory discrimination. "In order for an individual to judge whether two or more speech sounds are alike or different, or to make more difficult judgments, the sounds must be kept in memory and retrieved for comparison. ... Thus auditory discrimination is partially dependent upon auditory memory span"(p. 63).

5. Auditory sequencing is defined in relation to memory span. "Closely related to auditory memory span is auditory sequencing, the recall of sounds in proper temporal sequence; sequential behavior is necessary for the

acquisition of language skills"(p. 65).

Chosen from previous educational research for consideration in this study are three auditory skills from Witkin's model: acuity, auditory discrimination, and auditory memory span. According to Witkin, auditory discrimination and auditory memory span are related, as are memory span and sequencing. Thus in terms of Witkin's model, this research does not attempt to measure attention or tracking skills.

Pitch discrimination, a variable found to have been important in previous studies, has been added to this study in an effort to test its relationship to the skills just described. Rather than phonemic discrimination, pitch discrimination requires the listener to discriminate pure tones.

Intelligence has been added to this study in order to compare findings from previous studies which include intelligence, and in order to describe some possible relationships between intellectual ability and auditory scores. The definition of intelligence adopted for this research is operational: that ability reflected by scores from the Peabody Picture Vocabulary Test described in Chapter Three.

Though, as Witkin points out, there has been very little application to educational problems of the concepts just presented, we have long recognized that auditory skills are somehow critically related to school learning, particularly to learning to read. Thus the growth of

skills such as those just described is of interest if we are to make a profitable connection between ear abilities and beginning school success.

It is apparent that auditory skills during the pre- and early school period are often assumed through the development of expressive language skills; we typically gauge what a child knows through what he says or gestures to us (Zigmond and Cicci, 1968). Thus we tend to make judgments about auditory discrimination from the child's developing vocabulary and speech behavior. This also applies to his memory span and even to his acuity. In fact, an entire body of literature relates expressive language defects to auditory deficiencies and to reading disorders. Certainly the work of scholars such as Templin (1957) and Winitz (1959) is relevant to the reader interested in the relationship of articulatory growth to hearing and reading skills. Recently, the speech area has been expanded through the application of syntactical theory to the child's phonological development. This perhaps begins to explain the complicated and heretofore inconclusive relationship among variables such as articulation, hearing, and reading (Locke, 1968; Read, 1971). Though interesting, and certainly tangential to auditory growth, the school of research concerned with phonology is not considered central to this study.

Reading. When the child enters school, concerns about his progress are typically funneled into the more

specific concern that he learn to read adequately. There is an abundance of data to document the importance of learning to read. What is sometimes less clear is what "learning to read" means to each researcher when he writes about it. As it is a secondary purpose of this study to determine some relationships between developing auditory abilities and reading skills when formal training begins, it is appropriate to establish a definition of what we mean by reading.

Following an examination of many kinds of definitions, their strengths and their weaknesses, Wiener and Cromer (1968) discuss reading in terms of two sets of skills or processes, identification and comprehension:

> Identification presupposes a discrimination of one graphic symbol from others, and a transformation of these symbols from one form (usually visual) to a second form (usually auditory). The original visual forms and the transformed auditory forms are considered to be equivalent, differing only in that the referents are represented in different modalities . . . . Identification will be used to mean 'word-naming' in the context of a transformation of stimuli . . . our formulation comes from an analysis of visual-to-auditory transformation . . . (p. 635).

According to the same authors, identification or word-naming may occur in several ways. The child may respond to likeness as among graphic forms or among auditory forms in an incidental manner; he may systematically be taught to look for the same kinds of likenesses; or he may use rules to transform visual forms into specific sounds. (This also requires the ability to scan) (pp. 635-636).

> In our usage, comprehension refers to the addition of some form of meaning associated with the identifications or discriminations, i.e., the words elicit shared associations or consensual indicator responses to or about the referent, or a synonomous response . . . . It has been implied that meaning is available primarily through language as it occurs in the auditory form. We also have assumed implicitly that once there is a transformation from the visual to the auditory form, comprehension would follow. If the reader's auditory transformation (identification) corresponds to his already available auditory language forms, then meaning can be associated with the visual forms. . . . The assumed sequence has been: discriminations among input forms and output forms; transformation; identification, comprehension--all of these being required (p. 638).

To Wiener and Cromer, then, comprehension is concerned with that part of the reading process which lends meaning to the process of identification; preceding identification are two processes, discrimination and transformation.

Purpose of the Study

The specific purpose of this study is to investigate the following research questions:

1) is there a change over time in the child's hearing acuity?

2) is there change over time in the child's auditory discrimination for speech sounds?

3) is there a change over time in the child's auditory memory span?

4) is there change over time in the child's ability to discriminate pitch?

5) is intelligence related to the growth of auditory variables?

6) how do auditory acuity, discrimination,

memory, and pitch discrimination grow relative to each other?

7) how does the growth of auditory scores relate to the child's reading performance when formal instruction begins in grade one?

Questions like these have prompted the exploratory longitudinal design for the study reported here, primarily to generate more defensible hypotheses for future experimental studies concerned with causal relationships between various treatments and auditory growth. As more is learned about the growth pattern of hearing during the early school and preschool period, for example, it should be possible to formulate more meaningful hypotheses regarding the effects of classroom acoustic characteristics on auditory growth. Additionally, to the degree that this study provides a means of testing results from previous research instruments against a different design, the findings may well indicate that new instruments should be developed to be tested against prevailing models of auditory perception, such as those suggested by Witkin (1969) and Sabatino (1969).

Chapter Two

Review of the Literature

Introduction

The research related to this study has been reviewed in four sections: auditory acuity research, auditory discrimination research, auditory memory and auditory sequencing research, and pitch discrimination research. Most of the studies summarized here are concerned with the relationship between hearing and reading in the beginning school years. Thus research concerning reading--a secondary consideration in this study--has not been reviewed separately. For similar reasons, literature related to concepts of intelligence has not been separately reviewed. Instead, findings concerned with intelligence are reported as they occur in the studies reviewed.

Auditory Acuity Research

As pointed out by Witkin (1969), as well as by Goetzinger, Dirks, and Baer (1960), auditory acuity remains a central or primary concern in auditory perception. Pure tone acuity, which is more accurately a test than a measurement of hearing (Frisina, in Jerger, 1963), refers to the ability of the individual to perceive sound at threshold levels for differing frequencies across the sound spectrum, and to his ability to convey that information to the examiner. Scores are plotted in decibel loss at each

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

frequency level. A zero decibel tone, for example, is barely discernible in a soundproof facility; a 10 decibel tone is equivalent to an average whisper four feet from the speaker (Denes and Pinson, 1963). It is not uncommon for an individual's audiogram--the graphed result of his pure tone acuity test--to vary between zero and 15 decibels of loss, depending on the frequency. The phrase "hearing loss" is then used here as a reference to the acuity scores of normal children. Loss at 20 decibels is frequently a referral point for possible pathological loss.

As Poling (1968) indicates, many studies of auditory acuity are concerned with the prevalence of impaired hearing among school children, referral and measurement of hearing loss, and effective screening test procedures for use in schools. This body of research is not considered germane to the study described here, and is efficiently reviewed for the interested reader by Frisina (in Jerger, 1963).

Several major studies of hearing variables have included acuity, but only as a means of screening from their investigations children with poor hearing. Both Thompson (1963) and Poling, in their longitudinal studies (1968), incorporated auditory acuity simply as a means of insuring that each child in the experimental sample was free of hearing impairment.

In one of the few attempts to establish hearing norms for randomly sampled children, Eagles and Wishik

(1961) reported that children from three to seventeen years showed better sensitivity to pure tones than did adults. These authors also demonstrated that the standard audiometric technique used in this study, where the child signals when he hears a tone, can be used with children as young as three years of age.

The growth traits as implied by Eagles and Wishik, have been documented by Kennedy (1942); Price and Falck (1963); Eagles (1961); and by Siegenthaler, Pearson, and Lezak (1954), using varied audiometric techniques.

In 1935, Bond reported that "there is a difference in hearing acuity favoring good readers (p. 23)." Bond used a percentage of hearing loss rather than pursuing relationships between loss at differing frequencies and reading achievement. In other words, Bond averaged the decibel loss for each frequency tested and used that figure for the "best ear", when he related hearing to reading achievement (p. 23).

As described earlier, Kennedy (1942) found significant differences in acuity across age groups. In particular, she noted that the hearing of eight-year-olds was significantly more acute than that of six-year-olds, and that sensitive auditory acuity appeared to be an important factor in learning to read. She went so far as to state that a child with superior acuity has twice as much chance of becoming a good reader as a child with some, even minor, acuity impairment.

With grade five students in 1940, Betts found that 12 of his 78 students needed to be referred for possible pathological hearing loss, and that 6 cases with high frequency loss were among 30 who were below average on the reading achievement test. Generally, he reported that more low than high reading achievers had some degree of loss.

Summary. Acuity has been studied in the context of reading, and has been a means for screening impaired children from some research. Acuity has been found to improve significantly in early school years. High frequency loss seems to correlate with reading.

Auditory Discrimination Research

Wepman defined auditory discrimination as "the capacity to distinguish between phonemes, or individual sounds used in speech (1960, p.325)" and stated that discrimination skills often mature as late as the end of the child's eighth year. Though he brushed over the importance of memory in auditory discrimination, Wepman did point out the positive relationships between discrimination and reading and the low correlation with intelligence. As a warning against taking discrimination skills for granted, he stated:

> It is too often believed that when a child is able to hear, he is able to understand the spoken word; then, when he can understand the spoken word, he can discriminate each sound, he can moderate his own speech or

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

> attack new words in reading through phonics. The reasoning here is good, but the basic premise is faulty. Audition is not a function in which all of the parts are ready to work with equal facility at all times (p. 327).

Wepman cited the decreasing number of errors children tend to make on his test as they grow older as proof of the "developmental nature of discrimination (p. 331)" and made a plea for identifying and helping children with low discrimination skills before teaching them to read.

Durrell and Murphy (1963) made another plea: prior to reading instruction children who are low in auditory discrimination should be given training in this ability because it "responds well to teaching and when it is learned usually results in a marked increase in rate of learning to read (p. 560)." These authors stated that, although other skills such as visual discrimination and attention are important, "the child who learns to read easily is the one who notices the separate sounds in spoken words (p. 556)." It is in this skill, said Durrell and Murphy, that the poor reader is usually deficient. Basing their findings on previous research, the same authors found no relationship between auditory discrimination and intelligence.

Dykstra (1966), whose threefold categorization of auditory discrimination research was presented in the preceding chapter, identified a need for factor analytic and experimental studies, and for data describing the relationship between auditory discrimination and other hearing

variables. In a multiple-regression study relating pre-reading measures of auditory discrimination to reading achievement at the end of grade one (N = 632), Dykstra concluded that a prediction formula is impossible to construct from his research because auditory discrimination and intelligence "accounted for less than one-half of the variation in performance on the reading measures (p. 5)." It seems, then, that though auditory discrimination skills are an important part of the child's pre-reading repertoire, it is unwise to assess auditory skills using discrimination alone.

In a study of the relationship of auditory discrimination to beginning reading success, Goetzinger, Dirks, and Baer (1960) stated:

> Although hearing acuity for pure tones is usually regarded as a good index by which to evaluate auditory capacity, and hence to rule out hearing as a possible reason for poor school achievement, nevertheless, the other important aspect of hearing, namely auditory discrimination, perhaps deserves more attention than has hitherto been supposed (p. 121).

Blank (1968) also supported the hypothesis that auditory discrimination is often more of a problem for the poor reader than are other variables. In a note to teachers regarding the importance of auditory discrimination apart from acuity, Dixon (1970) stated, " ... discrimination difficulty is often overlooked because he (the child) passes the school hearing test (p. 91)." Dixon asked teachers to look for and test those children who could not recognize

differences in environmental sounds, speech sounds, or pitch and loudness levels.

In a recent study designed to explore differences between high and low socio-economic groups with auditory skills and reading ability, Flynn and Byrne (1970) found that advanced readers scored significantly higher on both auditory discrimination and pitch discrimination measures. These included the Wepman and Seashore tests. The researchers, who used subjects drawn from the third grades of four elementary schools, reported no significant differences between socio-economic groups, but they did report a high positive correlation between reading achievement and intelligence scores on the Lorge-Thorndike group test.

Two longitudinal studies of auditory discrimination reveal similar findings. Thompson (1963), using the Wechsler Intelligence Scale for Children, found that auditory discrimination and intelligence are highly correlated with success in primary reading, that discrimination and I.Q. are often positively related during the first school year, that discrimination in speech grows from the beginning of grade one, and that weakness in discrimination is often characteristic of children entering grade one. Thompson's findings are similar to those of Poling (1968), who found that children who enter grade one with superior auditory discrimination skills become, and remain, superior readers through grade two. She also reported growth in discrimination skills of grade one pupils, particularly of

those whose auditory discrimination skill was poor at the outset. Thompson (1963) supported this finding. From the evidence of school records, Poling found that there is a positive relationship between auditory discrimination and intelligence as these two factors relate to reading, but that the relationship is stronger with children in grade two than with those in grade one.

Summary. Though auditory discrimination and auditory acuity have not been investigated as possible correlates, discrimination has been identified as a correlate of early reading success. Discrimination skills have been shown to grow rapidly during the grade one period. Because many children do not have adequate discrimination abilities when they first enter school, researchers have recommended remediation for the skill before these children begin formal reading instruction. Results from cross-sectional studies of the relationship between discrimination and intelligence are inconclusive, though Thompson (1963) and Poling (1968) reported significant positive correlations as a result of longitudinal studies.

Auditory Memory Research

Auditory memory span refers to "the number of items that can be learned in one trial when they are presented serially at a controlled rate. Digits, words, pictures, or objects may be used, although the verbal items are the most common" (Hilgard, in Stevens, 1964, p. 547). Memory

those whose auditory discrimination skill was poor at the outset. Thompson (1963) supported this finding. From the evidence of school records, Poling found that there is a positive relationship between auditory discrimination and intelligence as these two factors relate to reading, but that the relationship is stronger with children in grade two than with those in grade one.

Summary. Though auditory discrimination and auditory acuity have not been investigated as possible correlates, discrimination has been identified as a correlate of early reading success. Discrimination skills have been shown to grow rapidly during the grade one period. Because many children do not have adequate discrimination abilities when they first enter school, researchers have recommended remediation for the skill before these children begin formal reading instruction. Results from cross-sectional studies of the relationship between discrimination and intelligence are inconclusive, though Thompson (1963) and Poling (1968) reported significant positive correlations as a result of longitudinal studies.

Auditory Memory Research

Auditory memory span refers to "the number of items that can be learned in one trial when they are presented serially at a controlled rate. Digits, words, pictures, or objects may be used, although the verbal items are the most common" (Hilgard, in Stevens, 1964, p. 547). Memory

manifested by both the inability to reproduce a sequence of discrete phonemes presented orally and the inability to blend a sequence of phonemes into a word or wordlike whole. Huffman and McReynolds (1968) agreed that such "sequential behavior is necessary for the acquisition of language skills (p. 178)," and emphasized the need for experimental work in the area. From a study of blending isolated German sounds into syllables, Locke (1969) reported that auditory memory is related to experimental sound learning, and that a relationship exists between auditory memory, I.Q. on group tests, and oral stereognosis--a haptic experience whereby the child explores various forms with the tongue and then identifies them on a chart of drawings.

Bach and Underwood (1970) describe two characteristics of memory for words, acoustic and verbal-associative:

> The acoustic attribute of the memory for a word is its sound patterning when pronounced. The verbal-associative attribute of a word consists of one or more other words which may be elicited by it. It is assumed that at the time of learning these two attributes may become a part of the memory for a word (p. 292).

On the assumption that the acoustic attribute might be dominant in the young child, Bach and Underwood tried to determine if developmental changes occur in the dominance of the two traits described above. The experimenters found no significant trends and some indication that the acoustic attribute is forgotten more quickly than the other (p. 296).

In an effort to determine the temporal position in

which auditory discrimination was most accurate, Doehring (1969) worked with 35 normal children and five children with "learning problems (p. 65)." His conclusion was that speech sound discrimination is most accurate when the odd auditory stimulus is in last position and least accurate when it is in initial position. In other words, when children are presented with three auditory stimuli, two identical sounds and one odd one, and are asked to indicate temporal position of the odd stimulus, they can do this most accurately when the odd stimulus occurs in final position. This finding, which has implications for auditory discrimination tests that may also involve some memory skills, brings us back to Witkin's reminder that auditory discrimination depends partially upon the auditory memory span (Witkin, 1969, p. 63).

Doehring was unable to explain why his subjects identified temporal sequence more accurately when the odd stimulus was in final position. Perhaps Warren and Warren (1970) provide a possible explanation in their effort to explain "temporal confusion (p. 33)" or "a failure in the detection of temporal order (p. 33)." From an exploration of verbal illusion, when "phonemic restorations are heard when the context is clear but part of the stimulus is absent (p. 35)," the authors noted, "The absence of illusory changes at age five suggests that young children have not yet reached the stage in language development where storage with skilled reorganization comes into play (p. 36)." The

Warrens' findings suggest that Doehring's subjects had not developed the perceptual equipment necessary to recall other than what they heard last. In keeping with educational studies that reported rapid growth in auditory memory during grade one (Neville, 1968), the Warrens also found that illusory change developed rapidly from ages six to eight.

Auditory memory and reading. For many years auditory memory has been acknowledged as a high positive correlate of reading achievement and intelligence. In 1931, Saunders, through a series of case histories, emphasized the importance to the young child of adequate auditory memory. In her early study, Poling (1953) found a significant positive relationship between the auditory memory of grade one children and their word recognition skills. Reynolds (1953) had similar results with grade four children.

In a study of poor readers, Rose (1958) noted that children with reading problems have more difficulty with the auditory memory subtests of the Stanford-Binet intelligence test than with any other subtest, and recommended that the trait be studied further as a predictor of reading achievement. With a similar population, Stauffer (1948) used several kinds of auditory memory tests and noted that poor readers do better on other tests than on the Betts (1936), an auditory memory test composed of sentences which the child repeats. Interestingly, Stauffer found it

impossible to categorize poor readers discretely. Raymond (1955) studied high reading achievers and found visual memory skills more highly correlated than auditory memory span, a result which tends to support Stauffer's finding. Raymond also found that speech-related auditory memory tests are higher correlates of superior reading achievement than are tests with unrelated content, such as those composed of digits. Correspondingly, Heckelman (1968) posed the possibility that reading may be an "instantaneous memory process (p. 231)."

In an experimental study done with first grade children, Neville (1968) found that auditory memory span grows rapidly in the first months of school. Neville also substantiated the conclusions of Poling (1953) and Reynolds (1953) by reporting a positive relationship between memory span and reading as well as between auditory memory span and word recognition skills.

Summary. It may be, then, that auditory memory span and auditory sequencing are powerful factors with some children as they begin school and learn to read. Correlations have been established with poor reading ability, intelligence, and some evidence has been offered to suggest that the traits grow during the first months of school. As yet, however, the growth characteristics of auditory memory span and of auditory sequencing skills have not been specifically explored, particularly as they relate to auditory discrimination and acuity.

Pitch Discrimination

Pitch discrimination, or the ability to determine whether two pure tones are alike or different, for example higher or lower, presents a contrastive measure to those discrimination instruments that determine differences between more complex sound combinations, such as those in speech. This trait has been studied as a correlate of other auditory skills, but not extensively.

In his factor analytic study of hearing, Karlin (1942) used the Seashore pitch subtest with high school students; he reported high loading on a pitch or frequency integration factor. Karlin issued an early caution about the relationship of isolated "pure" measures such as pure tone discrimination, stating that they were weak predictors of "more complex auditory abilities (p. 53)," such as hearing behavior in social situations.

Kennedy (1942) used the Seashore pitch subtest in grades five and above; she found a significant relationship between pitch discrimination and silent reading abilities. Ewers (1950) concluded that good reading ability included the power to discriminate between frequencies, thereby supporting Karlin's frequency integration factor. She related many different auditory abilities to reading and ended her study with a note that auditory researchers should relate their findings to theories of audition before interpreting them.

In an attempt to relate auditory discrimination skills

[illegible]

[illegible]

to silent reading, Wheeler and Wheeler (1954) found a significant correlation in grades four, five, and six between pitch discrimination and reading. This implies that the ability to discriminate differences in pitch may develop as late as the end of grade four, an implication that disagrees with Reid's finding (1962) that auditory discrimination for speech may have a developmental peak at grade three with strong growth during grades one and two. Wheeler and Wheeler used Seashore's pitch subtest in their study.

Results reported by Parker (1970) in a study of musical perception and reading indicated no significant difference between good and poor readers in pitch discrimination; they did, however, find significance with tonal memory. The study was done with 11- to 13-year-old children.

Summary. Pure tone pitch discrimination and its relationship to hearing and reading have been explored in a somewhat meagre fashion, typically with populations at grade five level and above and with varying results. The application of pitch discrimination tests in grade four and above is understandable in the light of findings such as those of Wheeler and Wheeler (1954). These suggest that the trait does not develop until at least that age. Relationships between pitch discrimination and discrimination for speech are inconclusive, and there has been no apparent attempt to relate pitch discrimination to auditory memory or to acuity.

Chapter Three

Method

Introduction

Auditory variables central to educational studies since the 1930's have been auditory acuity, discrimination for speech sounds, and auditory memory. The present study has included these variables, as well as pitch discrimination. Reading and intelligence as related to these variables has been a secondary consideration.

A descriptive repeated-measures design with a random sample and matched longitudinal format was adopted for this research. All of the variables just named (with the exception of reading) were tested in the sample at each time of measurement, and only those subjects who were present at every testing time were used for the final analysis.

To gain some idea about children's auditory growth before and after they enter school, the study began with observations of auditory traits over the half year before the children entered grade one, and it continued for approximately a half year after school attendance began. Measures of each auditory skill and of intelligence were individually administered to each child at four testing times over the year: three times before the children entered school and once after. Two short measures of

[illegible]

reading skills and an ear, nose, and throat examination were added at the final testing time. Also at the final testing time, a control group of 20 children was drawn at random from an elementary school in the same geographical area. The control group was given audiometric tests to help determine if there had been a significant practice effect from using the audiometer. The sample for this study was chosen from the middle income groups in the city. This was done for two reasons: first, the middle groups represented a majority population of the city (Kupfer, 1964); and second, the relative stability of the city's middle income families helped insure a low dropout-rate due to moving from the city.

The Sample

The sample for this study was selected in January, 1970, using the Kupfer study (1964) to identify the middle income areas in Edmonton, Alberta, where the research was conducted. Kupfer's study is a sociological description of the city in terms of income, mobility, and other variables. The three Kupfer areas which represented Edmonton's central income areas were made up of 12 census polling districts (Appendix A).

From records of the Edmonton Census Board compiled in December, 1969, a list was made of each family with a child who would begin school the following September; there were 215 families on the final list. The names of

the families were recorded in random order, then contacted by telephone until a total of fifty-four, eighteen from each area, had agreed to participate in a hearing study that would involve four visits to the university campus over the following year. The families were informed that transportation by commercial taxi would be supplied to and from the campus, and that school schedules would not be interrupted for testing after the children began grade one the next fall.

Over the year of testing, five children dropped out of the study, bringing the final sample number to 49. Two were ill at the first testing time, one was unable to begin grade one because of apparent learning disabilities, and two families moved from the city.

The Instruments

The overriding criteria for selecting the instruments used in this research were twofold. First, one of the major purposes of the study was to compare its results with those of previous educational findings based on another type of research design. Second, it was necessary to choose a battery of instruments that would provide a comprehensive set of auditory, intellectual, and reading data in a period of time that would tax neither the children nor their parents. Tests were thus chosen on the basis of previous research, and consideration was given to selecting tests that would present a relatively brief and pleasant

experience for the children as a way of ensuring continued participation.

Acuity. As in other studies dealing with auditory acuity and the classroom, an audiometer was used in this study to measure pure-tone acuity. Testing was done individually in a soundproof booth using the technique whereby the child signalled when he perceived a tone. This is an audiometric technique requiring very little training time per child, and there is evidence to demonstrate its appropriateness with five-year-old children (State of Illinois Monograph, 1969; Lowell, 1956; Frisina, in Jerger, 1963). Maico portable audiometers, model MA-12, and the accompanying headsets were used. Test-retest reliability figures for the audiometers were not available (Buros, 1965, p. 947). The machines were calibrated by professional technicians prior to each testing time to ensure minimal error due to machine inaccuracy. In keeping with recommendations from the Illinois study (1969) acuity in each ear was tested at 250, 500, 1000, 2000, 4000, and 8000 Hz.

Discrimination. The Wepman Auditory Discrimination Test (1958) was chosen to test discrimination for speech sounds. The test has been an excellent predictor of reading achievement (Poling, 1968) and has a test-retest reliability coefficient of .91 (Wepman, 1958). The Wepman test has 40 items composed of 80 words in minimal pairs. Differing phonemes occur in all word positions and

allegedly represent the frequency spectrum (Poling, 1968).

Memory. On the basis of a finding from Rose (1958), the auditory memory subtests from Form L-M of the Stanford-Binet were used at the first testing time to assess auditory memory skills. In order to provide a more precise measure of auditory memory span, the Betts sentences from the Betts Readiness Tests (c. 1934-1938) were used through the remaining three testing times. The Betts test requires from five to eight minutes per child and measures auditory memory span for speech in the context of twenty sentences.

Pitch. The ability to discriminate pitch was assessed by the first ten tone pairs from the Pitch subtest of the Seashore Measures of Musical Talents (Seashore, Lewis, and Saetveit, 1960). These ten pairs are the simplest items from the subtest and require about two minutes to administer.

Intelligence. Though limited inter-form reliability has been reported for the Peabody Picture Vocabulary Test--a receptive vocabulary measure--it was chosen for use in this study as "the best of its kind" (Piers in Buros, 1965, p. 530)--a short, pleasant test normed for intelligence. Testing time per child ranged from five to seven minutes. Intelligence scores from the Peabody test have shown a correlation of .84 with full-scale I.Q. scores from the Wechsler Intelligence Scale for Children (Moed, Wight, and James, 1963). According to the same authors, "The PPVT was more difficult than the other tests but showed greater

concurrent validity with the W.I.S.C. (p. 363)" than did another short picture vocabulary test.

Reading. The reading instruments administered at the last testing time were chosen to provide a brief measure of both identification and comprehension skills as described by Wiener and Cromer (1968). Because the last testing time was only five months after the children began formalized reading instruction in grade one, tests had to be very simple to display maximum variance. For a measure of word recognition skills--which would fall under the Wiener-Cromer category of identification--the Roswell-Chall Diagnostic Reading Test of Word Analysis Skills (Chall, 1958) was used. This test, which requires about five minutes per child, is divided into six subtests arranged in "the order in which word analysis skills are usually taught" (Chall, 1958, p. 179). Validity coefficients with second graders have been reported as .91 with standardized Tests (Chall, 1958, p. 181).

For a measure of oral accuracy and oral comprehension, the Neale Analysis of Reading Ability was added to the study (Neale, 1958). The Neale test requires about ten to fifteen minutes per child. Buros (1965, p. 1134) reports a correlation coefficient of .94 to .95 between the Neale test and the Schonell Graded Word Reading Test based on nine- to eleven-year-old children.

Medical. The questionnaire used during the children's medical examination at Time Four was devised by

the examining pediatrician and approved by a local otolaryngologist. The questionnaire was employed as a means of describing the physical condition of the children's ears, noses, and throats in case organic problems might be present.

Equipment

All of the testing for this study, excepting the reading assessments, the medical tests, and the audiometric tests for controls, was conducted individually in an Industrial Acoustics Company soundproof booth with external dimensions measuring 8 1/2 by 7 1/2 feet. All equipment necessary to the testing was placed inside the booth, including chairs for the examiner and the child.

Testing for the control group was conducted in a quiet room in the elementary school from which the children were chosen. The Wepman Auditory Discrimination Test was tape-recorded inside the soundproof booth so that administration could be standardized. The machine used to record and to play the tape was a Sony monaural model TC-105 with a model MTL-F96 microphone. The tape was played at the same volume for each individual assessment.

The Seashore pitch subtest disc was played on a Rheem Califone monaural phonograph, Model 12 MV. Before each testing time, a qualified technician checked the turntable to standardize revolutions per minute. Volume was standardized for all administrations.

[illegible]

The Peabody Picture Vocabulary Test and the Betts sentences were administered verbally by the examiner to each child inside the booth. Chair position was constant during all testing times.

Reading and medical tests were administered individually in small quiet rooms adjacent to the soundproof booth.

Test Procedure

Testing times for the study were as follows:

Time One	---	February, 1970
Time Two	---	May, 1970
Time Three	---	August, 1970
Time Four	---	January, 1971

Each testing time lasted approximately two weeks. During each time, children were given alternate forms of the Peabody Picture Vocabulary Test; a pure tone audiometric assessment with frequencies tested at random for each ear; the Wepman Auditory Discrimination Test, Form A; the first ten items from the Seashore pitch subtest; and the Betts sentences. Tests were administered in random order, determined by the children who drew the names of each test from a hat. At the first testing time it was sometimes necessary to administer the audiometric test in several parts because of the anxiety of the subject. Test time per child for the entire battery ranged from 25 to 40

[illegible]

[illegible]

[illegible]

minutes.

At the final testing time the children were given the Roswell-Chall and the Neale reading tests immediately after they had finished the audiometric battery. Ear, nose, and throat examinations were individually administered to all children at Time Four by a local pediatrician and her husband, an intern at the University Hospital.

Examiners. All testing at Time One and Time Three was done by this researcher. At Times Two and Four a second examiner tested half the children at random in order to control for possible experimenter effect, even though Hipskind (1969) had reported no significant differences in audiometric results as between different examiners. The second examiner, also female, was a qualified reading specialist with the local public school system. She had had extensive experience with pure tone acuity testing. Reading tests were administered by a trained research assistant.

Chapter Four

Analysis, Results, Related Findings

Analysis

Growth traits of the hearing skills explored in this study were analyzed by examining their means and standard deviations over time. Significance of change was tested for each set of means using a one-way analysis of variance for repeated measures data. Newman-Keuls multiple contrast comparisons were then made on pairs of means to determine at which times of measurement significant change had occurred. Means were graphed to examine how auditory variables grew relative to each other. Significance of the comparisons between audiometric data based on the experimental group at Time 4 and the control group was tested using t-tests for independent data. The t's for independent data were also used to test for differences between examiners at Time 2 and Time 4.

Relationships between the auditory variables, I.Q., and chronological age were explored with Pearson's r, a product moment correlation technique. Comparison of auditory scores and reading scores at Time 4 was also made using Pearson's r.

As it is the purpose of exploratory research to generate as many reasonable hypotheses as possible, a relatively generous significance level of .05 was set for

the overall study. The conservative F, which allows fewer degrees of freedom than the conventional F, was employed to interpret the significance of analysis of variance data to guard against any problems associated with the violation of the homogeneity of covariance assumption that is inherent in repeated measures designs (Kirk, 1968, p. 143).

Results

The data from this study have been summarized below as they relate to each of the six research questions presented in Chapter One. Findings related to the study are presented separately.

1. Is there a change in the child's hearing acuity over time? Table 1 shows acuity scores for each ear (L = left, R = right) at each frequency tested. Scores are reported in mean decibel loss for each time of testing; standard deviations are reported below each mean score. It is apparent from Table 1 that both mean decibel loss and variance decreased over time, indicating that acuity did change, along with the dispersion of scores. With the exception of the 8000 Hz level at Time 4, acuity increased and scores became less dispersed. The same trend occurred at 8000 Hz until Time 4, when both mean loss and variance were greater for both ears than at Time 3.

One-way analyses of variance for repeated measures yielded ten significant F's from the 12 frequency levels,

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Table 1

Means and Standard Deviations for Hearing Acuity Scores in Decibel Loss at Various Frequencies

		Time 1	Time 2	Time 3	Time 4
L250*	mean	16.224	11.224	9.693	10.714
	s.d.	8.928	8.631	6.242	6.383
R250*	mean	15.000	11.530	11.020	10.102
	s.d.	7.306	7.004	6.482	5.488
L500*	mean	15.918	11.122	11.224	9.081
	s.d.	8.700	7.378	6.810	6.347
R500*	mean	15.510	12.653	10.816	7.959
	s.d.	7.306	7.004	6.482	5.488
L1000*	mean	11.122	8.979	7.346	5.612
	s.d.	6.146	8.035	6.046	5.365
R1000*	mean	11.734	10.000	7.448	4.897
	s.d.	7.037	7.772	6.624	5.050
L2000*	mean	9.285	5.918	4.489	4.081
	s.d.	7.430	5.743	5.424	5.465
R2000*	mean	9.489	5.612	5.204	4.795
	s.d.	6.940	5.461	5.200	5.586
L4000	mean	9.285	9.183	7.448	6.938
	s.d.	7.569	9.183	6.624	6.983
R4000	mean	7.857	6.983	7.244	5.204
	s.d.	7.839	7.487	6.851	5.769
L8000*	mean	14.183	12.755	8.673	11.326
	s.d.	9.701	10.260	8.884	8.706
R8000*	mean	12.959	9.489	6.428	9.489
	s.d.	8.655	9.802	6.846	9.695

* Significant F ratios; see Appendix B.

indicating that acuity change over time was significant in both ears at the .05 level for all frequencies tested except at 4000 Hz. Frequencies showing significant change are starred in Table 1; analysis of variance data are summarized in Appendix B. Newman-Keuls contrast comparisons show that significant change occurred at L250 and L500 between Times 1 and 2, 1 and 3, and 1 and 4. In other words, change from Time 1 to all other measuring times was significant. At R500, L1000, R1000, and L2000, change was significant only between Times 1 and 4. At L8000 and R8000, significant change occurred between Time 1 and Time 3. The Newman-Keuls test revealed no significant difference between means at R250 or R2000, even though the conservative F's were significant.

2. Is there change over time in the child's auditory discrimination for speech sounds? The mean error scores and standard deviations from the Wepman Auditory Discrimination Test at Times 1, 2, 3, and 4 are shown in Table 2. The test contains 40 items.

Table 2

Means and Standard Deviations for Error Scores on the Wepman Auditory Discrimination Test

	Time 1	Time 2	Time 3	Time 4
mean	10.326	6.673	4.489	3.795
s.d.	7.765	6.414	4.325	5.094

Table 2 shows that the mean error score decreased at all four times of measurement as did variance until Time 4, when dispersion increased. A one-way analysis of variance for repeated measures was applied to the Wepman test scores to test for significance of change over time at the .05 level of significance. Results were significant as reported in Appendix B. Newman-Keuls tests indicated that a significant change occurred between Times 1 and 3 and between Times 1 and 4.

3. Does the child's auditory memory span change over time? As the Binet auditory memory subtests were used at Time 1 to measure auditory memory span, product moment correlations were employed to investigate their relationship to the other auditory variables. There was one significant correlation between memory and auditory discrimination for speech, as shown in Table 3.

Table 3

Correlation Between Errors on the Wepman Auditory Discrimination Test and the Auditory Memory Subtests of the Stanford Binet at Time 1

	Wepman
Binet	-.239

At Times 2, 3, and 4, the Betts sentences were used to measure auditory memory span. Means and standard deviations for the 20-item Betts test are presented in Table 4,

indicating that memory span errors increased between Times 2 and 3, and decreased between Times 3 and 4. Variance followed a different pattern, increasing between Time 2 and Time 3, and decreasing slightly between Time 3 and Time 4.

The one-way analysis of variance for repeated measures for the Betts test at Times 2, 3, and 4 was significant at the .05 level, as is reported in Appendix B. According to results of the Newman-Keuls test, change was not significant between pairs of time means.

Table 4

Means and Standard Deviations of the Number of Correct Responses to the Betts Sentences

	Time 2	Time 3	Time 4
mean	13.530	11.857	13.979
s.d.	4.765	5.263	5.064

4. Is there change over time in the child's ability to discriminate pitch? Means and standard deviations of error scores are reported below for the pitch subtest from the Seashore Test of Musical Talents. As Table 5 indicates, means decreased over Times 1, 2, 3, and 4; variance followed an irregular pattern, increasing between Times 1 and 2, and between Times 3 and 4. Variance decreased between Times 2 and 3. The one-way analysis of variance for repeated measures was significant as reported in Appendix B, indicating that there was significant growth in pitch

discrimination scores over time. The Newman-Keuls test showed no significant change between pairs of means.

Table 5

Means and Standard Deviations of Error Scores on the Pitch Subtest of the Seashore Test of Musical Talents

		Time 1	Time 2	Time 3	Time 4
Seashore (errors)	mean	4.734	4.632	3.428	5.387
	s.d.	2.921	3.333	2.715	2.956

5. Is intelligence related to the growth of auditory variables? Product moment correlations were employed in this study to describe the relationship of intelligence to the hearing variables. Significant correlations (at the .05 level) are reported below in Table 6 for each time of measurement. Acuity scores were recorded in decibel loss; the Wepman and Seashore test results in total errors made. Betts test scores were recorded as the total number right. The records of scores in both negative and positive integers resulted in many negative correlations, thus indicating a positive relationship between two negatively recorded variables.

Table 6

Significant Correlation between Auditory Variables and I.Q. Measures by the Peabody Picture Vocabulary Test

Time 1		Time 2		Time 3		Time 4	
Wepman	-.309	Betts	.328	Betts	.358	Betts	.424
L1000	-.236	L250	-.460	Wepman	-.251		
		R250	-.409	R2000	-.325		
		L500	-.427				
		R500	-.396				
		L1000	-.413				
		R1000	-.307				

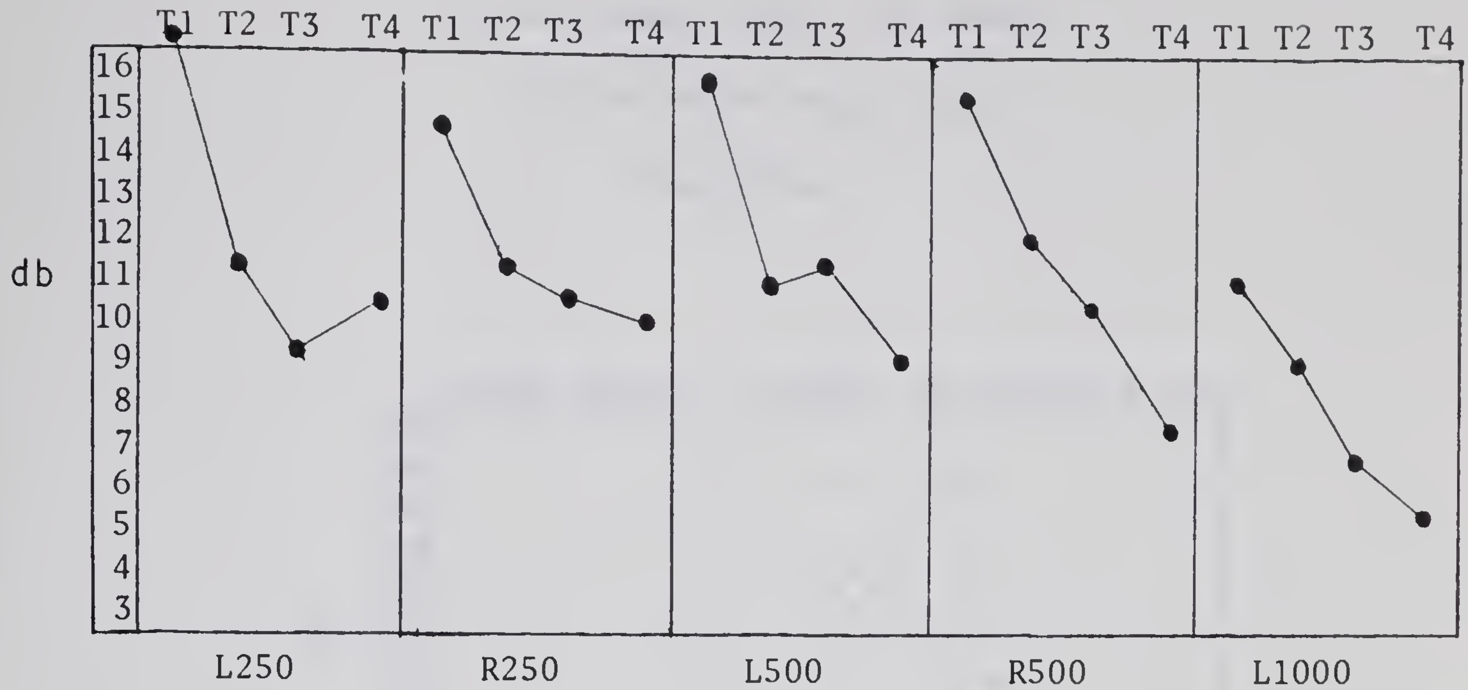
The foregoing shows that intelligence scores from the Peabody Picture Vocabulary Test were significantly correlated with auditory discrimination at Times 1 and 3, with the auditory memory scores at Times 2, 3 and 4, with a single frequency level at Time 1 and Time 3, and with scores from six frequency levels at Time 2.

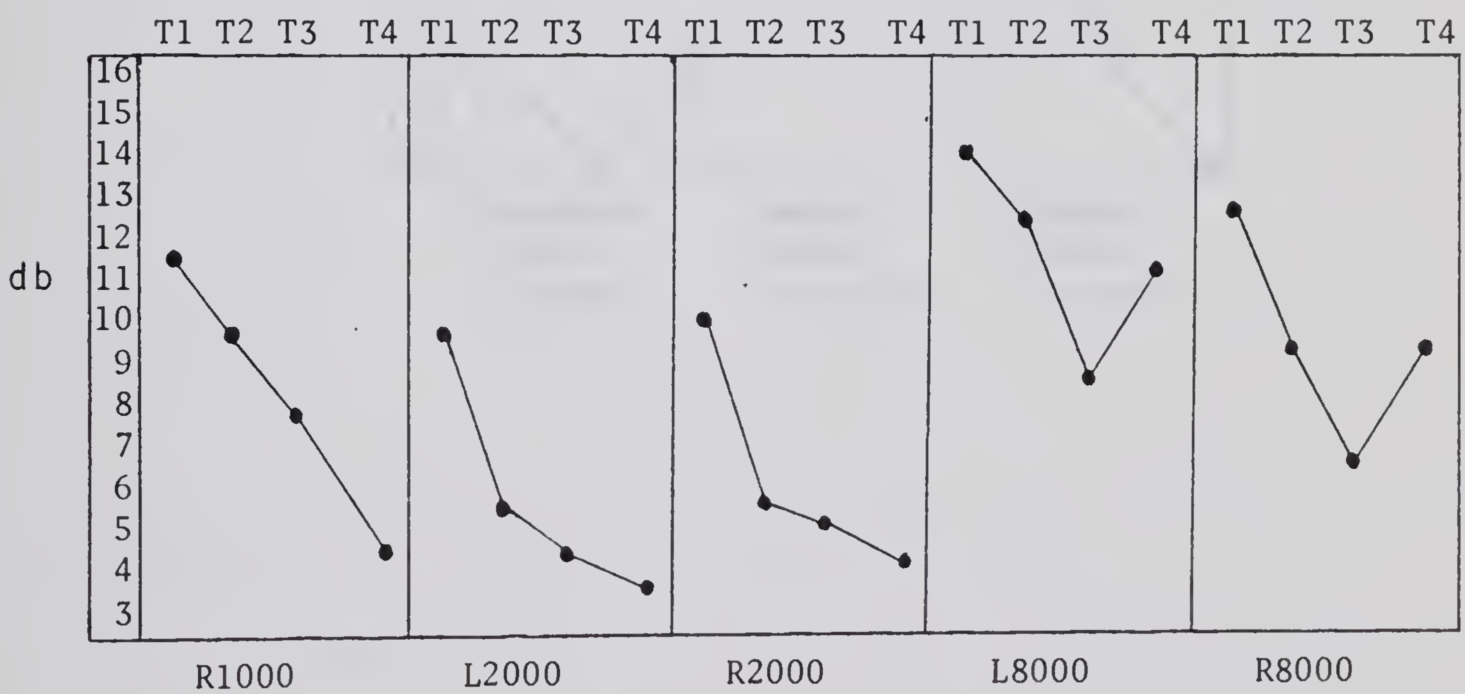
6. How do the auditory skills listed above grow relative to each other? Tables 7 and 8 present graphed means over Times 1, 2, 3, and 4 for the acuity variables, and for means from the Wepman, Seashore, and Betts instruments. It should be remembered that there is more time between Times 3 and 4 than between the other times.

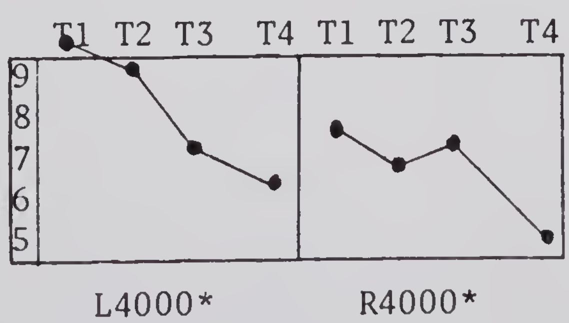
Table 7 shows acuity means over time and indicates a tendency for means to decrease, except between Times 3 and 4 at L250 and in both ears at 8000 Hz; change over time was significant in both ears except at 4000 Hz. The downward trend on the graphs indicates a decrease in errors or a general increase of sensitivity or acuity over time.

Table 7

Acuity Mean Change Over Time (In Decibel Loss)







*No significant change over time

Table 8

Pitch, Memory Span, and Speech

Discrimination Mean Scores

Over Time

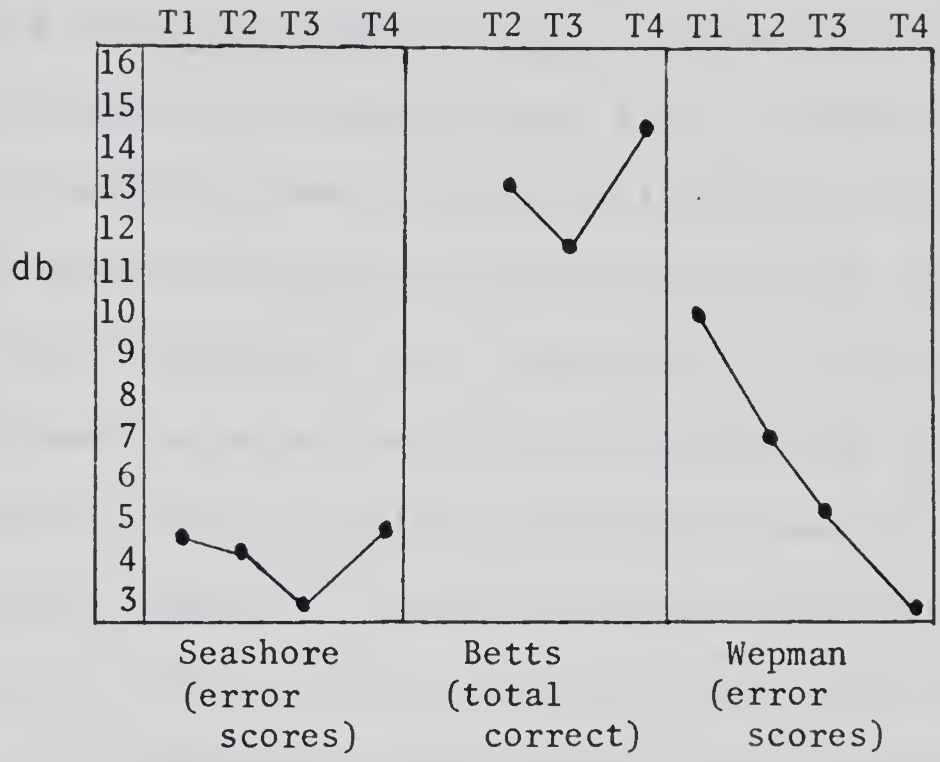


Table 8 contains graphs of auditory discrimination, pitch discrimination, and memory span scores. Here, the Wepman test error scores follow the same downward trend as the 1000 and 2000 Hz levels in both ears, while Seashore scores decrease in mean error between Times 2 and 3, with an increase at Time 4. Memory scores from the Betts test dipped slightly at Time 3 and improved at Time 4; these are recorded as <u>total number right</u>. Thus, auditory discrimination improved steadily over time. Pitch discrimination followed the same course until Time 4, when mean errors increased analagous to acuity scores at 8000 Hz, and at 250 Hz in the left ear (Table 7). Betts test scores followed an opposite pattern, improving at Time 4.

Pearson r's for acuity levels at Times 1, 2, 3, and 4 show a large number of significant correlations between all variables. These are consistent over time (See Appendix C). Frequency levels appear to be correlated with neighboring frequencies in both ears as well as with frequencies across the spectrum, with some decreasing relationships at Time 3 for R250 and R500 Hz.

At Time 1, the Wepman test results correlated significantly with L1000, and the Seashore test results with L4000 Hz. At Time 2, the Betts test results correlated significantly with one frequency level--L8000. The Wepman test results, at Time 3, correlated with R250, R1000, and L4000. The Seashore test results correlated significantly with R250 at Time 3 as did the Wepman. Additionally at

[illegible]

Time 3, the Seashore test results correlated with L250, L500, L1000, and R500. The Betts test results correlated negatively with R8000 at Time 3. At Time 4, the Wepman test scores were significantly correlated with R500, L2000, R4000, and R8000. The Seashore test scores correlated significantly with R2000, and L4000 at Time 4. Appendix C contains the correlation matrices just discussed; correlations significant at the .05 level are starred.

Acuity level seemed to be related to many other acuity levels over time, while the auditory discrimination, memory, and pitch discrimination measures were related to different groups of acuity levels at each measurement time.

The Wepman-Seashore correlation was significant at Times 1 and 4; the Wepman-Betts correlation was significant at Times 2, 3, and 4.

The Newman-Keuls tests indicate that L250 and L500 follow the same kind of developmental course, as do R500, L1000, R1000, and L2000, L8000 and R8000.

7. <u>How does the growth of auditory scores relate to the child's reading performance when formal instruction begins in grade one?</u> As Table 9 shows, there were three significant correlations (starred) between the reading measures and the Wepman, Seashore and Betts scores.

[illegible]

[illegible]

[illegible]

[illegible]

Table 9

Reading and Auditory Correlations

	Wepman (errors)	Seashore (errors)	Betts (total correct)
Roswell-Chall (total correct)			
Single C	-.031	-.308*	.336*
C Blends	-.018	.022	.222
Short V	-.187	-.122	.197
Neale (total correct)			
Accuracy	-.178	-.229	.242
Comprehension	-.114	-.087	.351*

Phonics scores from the Roswell-Chall test are recorded by subtests for various combinations of consonants (C) and vowels (V). The Neale test scores represent total the number of words read accurately and the number of questions answered correctly about the stories read. The starred correlations are significant at the .05 level.

Table 10 shows the significant reading and acuity correlations.

Table 10

Reading and Acuity Correlations (in decibel loss)

Roswell-Chall (total correct)	R500	L2000	L8000
Single C		-.251	-.306
C Blends	.274		
Short V			
Neale (total correct)			
Accuracy			-.268
Comprehension			

As mentioned previously, reading measures were given

[illegible]

at Time 4 only and were analyzed relative to Time 4 auditory data.

Related Results

Findings related to the research reported here are reported in five sections. These are related to: the audiometric control group, change in I.Q. scores, differences between examiners at Time 2 and Time 4, the medical examination, and chronological age.

Audiometric control group. To see if there were significant differences between the audiometric scores of the children who were tested at all four times and the control group of 20 children tested at Time 4, multiple t-tests for independent data were applied; these yielded significance at the .05 level for two of the twelve frequencies tested--at 500 and 4000 Hz in the right ear. Means and standard deviations are reported below for Group 1 (children who were tested four times) and for Group 2 (controls group). Significant pairs are starred.

Table 11

Audiometric Data-Differences Compared to Controls

Frequency		Group 1	Group 2
L250	mean	10.71	11.75
	s.d.	6.37	5.20
R250	mean	10.10	12.25
	s.d.	4.95	5.50
L500	mean	9.08	11.75
	s.d.	6.35	3.35
*R500	mean	7.96	12.75
	s.d.	5.49	3.43

Table 11 (ctd.)

Frequency		Group 1	Group 2
L1000	mean	5.61	6.00
	s.d.	5.05	5.50
R1000	mean	4.90	7.25
	s.d.	5.05	5.50
L2000	mean	4.08	5.25
	s.d.	5.47	6.78
R2000	mean	4.80	7.50
	s.d.	5.59	5.26
L4000	mean	6.94	7.25
	s.d.	6.98	4.99
*R4000	mean	5.20	8.75
	s.d.	5.77	6.46
L8000	mean	11.33	10.75
	s.d.	8.71	8.78
R8000	mean	9.49	10.25
	s.d.	9.70	7.86

Results from Table 11 indicate that, with the exception of 500 and 4000 Hz in the right ear, there were no significant differences in acuity scores between the controls and the participating children at Time 4, although in all cases except one, controls showed higher losses.

<u>I.Q. scores</u>. Though not directly related to the research questions posed for this study, the change in intelligence scores over time is of interest. I.Q. scores are based on the Peabody Picture Vocabulary Test, a receptive vocabulary measure. Mean scores and standard deviations are reported in Table 12.

<u>Table 12</u>

I.Q. Means and Standard Deviations Over Time

		Time 1	Time 2	Time 3	Time 4
I.Q.	mean	104.511	109.836	111.020	110.326
	s.d.	16.070	15.906	16.958	16.562

A one-way analysis of variance for repeated measures indicates that there was significant change in I.Q. scores over time at the .05 level. Results are reported in Appendix B. Newman-Keuls test scores show that change was significant between Times 1, 2, and 3, and Times 1 and 4. Intelligence scores were positively related to the comprehension subtest of the Neale reading instrument at Time 4, with a significant correlation of .350.

Differences between examiners. At Time 2, a second female examiner tested half of the children at random. Children were randomly assigned by incoming pairs, one to each examiner. Two significant differences between examiners at the .05 level at Time 2 were identified using independent t-tests. One difference was at R500 and the other at L1000.

At Time 4, testing was begun by the same two examiners, reversing groups from Time 2. The order was changed to accommodate the illness of the second examiner, however, so that this researcher tested 31 children, the second examiner 18. There were no significant differences between examiners at Time 4, except with the Betts sentences.

Probabilities for two-tailed tests were used to interpret the independent t data.

Medical examination. The checklist used to describe the ear, nose, and throat conditions of the children at Time 4 yielded results summarized in Table 13. This table indicates the number of children with each condition.

Table 13 shows that ears were normal for most children except for twelve with wax occlusion and one with external otitis. Eardrums were normal, again excepting the twelve children with occlusion. Two had injected drums, two had serious otitis, and three had scarred eardrums. Noses were normal except for seven with allergic mucous, and fourteen with congesting and discharge. Eighteen children had hypertrophied tonsils, fifteen had normal tonsils, two children had inflamed tonsils and four had had their tonsils removed. Cervical lymph nodes were normal except for nine children with enlarged and three with shoddy nodes.

Table 13

Medical Questionnaire

Ears		
a.	Canals	
	Normal	36
	External otitis	1
	Occluded with wax	12
b.	Drums	
	Normal	30
	Not visible due to wax	12
	Injected	2
	Serious otitis	2
	Scarred	3
Nose		
	Normal	28
	Congested mucosa (allergy)	7
	Congested mucosa (discharge)	14
Tonsils		
	Normal	25
	Absent	4
	Inflamed	2
	Hypertrophied	18

[illegible]

[illegible]

Table 13 (ctd.)

Medical Questionnaire

Cervical Lymph Nodes	
Normal	37
Enlarged	9
Shoddy	3

Chronological Age. Table 14 lists correlations that represent significant relationships between C.A. and other variables in this study.

Table 14

Significant Correlations with Chronological Age

	T1	T2	T3	T4
C.A.	Wepman	L8000 R8000 Wepman Seashore Betts	Betts	L8000 R2000 Betts

As Table 14 demonstrates, chronological age is significantly related to the Wepman test at Times 1 and 2; to the Betts test at Times 2, 3, and 4; to L8000 Hz at Times 2 and 4; and to R2000 Hz at Time 4.

Chapter 5

Discussion

The primary purpose of this study was to examine, through a longitudinal design, the extent to which hearing skills grow in children during the half year before and the half year after they begin school and to compare these results with data from cross-sectional studies. A secondary purpose was to relate hearing scores to beginning reading scores.

Auditory acuity. Results from this research indicate that acuity changed significantly over time except at one frequency level, as reported in Chapter 4 (p. 41). This finding supports those of Kennedy (1942), Price and Falck (1963), Eagles (1961), and Sieganthaler, Pearson, and Lezak (1954). Though it was not statistically significant, the drop in acuity scores at L250, L8000, and R8000 at Time 4 is difficult to explain from these data alone. Environmental, climatic or upper respiratory factors may have been responsible for the lower scores, or these frequencies, like pitch and memory, may have followed a developmental path slightly different from that of the other variables tested in this sample. As the children were in formal classroom settings only during the time that acuity scores were depressed, some set of classroom acoustic characteristics may have been an interruptive or an interactive factor.

[illegible]

[illegible]

[illegible]

[illegible]

It is interesting that the Newman-Keuls tests showed significant change in pairs of scores only between Time 1 and one or more of the other times of measurement. There were no significant changes in scores, for example, between Times 2 and 3 or between Times 3 and 4 for acuity or for the other auditory variables tested. This finding strongly supports an hypothesis of practice or retest effect with the instruments and the testing situation. Such an hypothesis assumes that the strangeness and newness of the testing environment and instruments depressed scores at Time 1 and that the *experience* of Time 1 was partly responsible for higher scores thereafter. The Newman-Keuls tests on acuity scores indicate that it was the low mean score at Time 1 which increased the range of scores, thereby suggesting that the pattern of change might not otherwise have been significant. Thus the relatively poor scores from Time 1 have been interpreted as being largely a result of test naivete shown in a practice effect.

An interpretation of Time 1 scores based on effects of test naivete can perhaps be clarified with a description of the initial testing period. It was the examiner's observation that the children appeared more anxious at Time 1 than at the other times. Understandably, many five-year-olds were emotionally affected by a first trip to a large building on a strange campus, by crowded elevators filled with noisy university students, and by the often crowded waiting room. Then the examiner, a stranger, immediately

took the child to a formidable cube-shaped sound booth full of machines that felt and sounded strange from the inside when the door was closed.

Also, undergoing an audiometric test with a headset for the first time can be an acoustically confusing experience for anyone. First, the "soundlessness" of the booth is strange to new ears; and second, a headset confronts the wearer with many new noises from the machine and from inside his own head (a kind of seashell effect). Sorting out a tiny single pure tone from all of the new sounds in his environment is an appreciably different kind of task for many children and one which anxiety caused by unfamiliar surroundings would likely complicate. Finally, the children had to listen to and act on five sets of instructions during the first testing time. Some of the instructions were lengthy and complicated.

During Time 1 the children received a large amount of positive reinforcement from the examiner. This, in combination with familiarisation related to the testing method and environment, could explain the statistical significance in error decrease between Time 1 and the other testing times. The negligible dropout rate from this study, plus the mothers' volunteered testimony that the children looked forward to Times 2, 3, and 4, would indicate that negative effects of test naivete were largely absent after Time 1.

Because it is not possible from these data to determine the precise amount of acuity score change due to test

newness or anxiety at Time 1, it is difficult to say how much decrease would have occurred <u>without</u> the alleged practice effect. If one accepts the assumption that little or no test anxiety was present at Times 2, 3, and 4, it is possible to conclude that change in acuity scores from Time 2 to 3 and from Time 3 to 4 was perhaps a more accurate reflection of the children's capacity to perceive pure tones. There was also a general pattern of improved acuity scores over Times 2, 3, and 4 (shown by decrease in error score), which suggests the presence of at least another affecting variable.

There is a possibility, therefore, that decibel loss would have decreased somewhat between Times 1 and 2 without a practice effect, for example, if there had been a practice testing time prior to Time 1. This possibility, coupled with the pattern of improved acuity over Times 2, 3, and 4, points toward some developmental change in pure tone hearing scores. It would seem plausible that change from Times 2 to 4 could be predominantly attributed to development. This discussion of practice effect and development may be applied to all auditory variables tested, and not to acuity scores alone.

If we were to interpret change over time from a statistical standpoint, it would seem that developmental change, though perhaps present, was not statistically significant, a conclusion supported by the Newman-Keuls

analyses which demonstrated significance only between Time 1 and one or more of the other testing times. Thus we conclude that, in the sample tested, there was some developmental change which was not significant, either in the three months before the children began school or in the five months afterward.

At R250 and R2000, where analysis of variance yielded a significant conservative F ratio, Newman-Keuls comparisons did not identify significance between pairs of means. The overall pattern of change was significant, but differences between times of measurement were not, a finding which may be attributable to less practice effect at Time 1 for these frequencies and to relative lack of statistical power in the Newman-Keuls test.

As expressed previously, other researchers have found significant increase in pure tone acuity (significant decrease in decibel loss scores) in children of the same ages as those in this study. Previous researchers have reported simple significant change in acuity scores over time, either between two or more testing times in longitudinal studies, or between children of differing ages in cross-sectional research. Thus, although studies prior to this one have reported the significant improvement of acuity over time, the major interpretive suggestion has been a developmental one, perhaps because other researchers have not considered a practice effect. Most other longitudinal research involves only two testing times rather than four

which would make effects from practice difficult to detect. There is no actual conflict between these findings and those reported earlier--whether from studies with longitudinal or cross-sectional design--but the interpretations differ because effects of practice on auditory scores have not prior to this time been considered. Previous studies have not suggested the effect of test familiarity as a major intervening factor in the growth of acuity scores or of other auditory variables.

To determine how much practice affects hearing scores in beginning school children, one could conduct a study which, as suggested earlier, would allow us to separate variance due to practice effect from that due to growth or developmental influence. Such separation could be accomplished by using two groups, one that is exposed to a practice measuring time (before Time 1 in this study), and one that is not.

In summary, these results do not conflict with those from other research: they simply propose alternative explanations for significant improvement over time in pure tone auditory acuity scores as well as for the other variables tested.

Auditory discrimination. Auditory discrimination scores as measured in this study rose significantly, as indicated by a decrease in Wepman error score. This supports findings from Wepman (1960), Thompson (1963), and Poling (1968), who indicate that this skill grows rapidly

among children of the age range of the population in the present study. These researchers, however, state that the skill grows rapidly after children enter grade one. Statistically significant change for speech discrimination in this study occurred between Time 1 and Times 3 and 4; Time 1 measurements occurred a half year <u>before</u> children entered school. Thus the <u>pattern</u> of change in discrimination scores from these data is the same as that from the Wepman, Thompson, and Poling studies, but the initial time of measurement differs in relation to the time of school entrance. This finding would lead us to question some of the conclusions from earlier research. The rapid growth in children's auditory discrimination scores during grade one (a growth not apparent in this study) may have been due to practice effect from the first measuring which, in the earlier studies, occurred when the children began grade one, not, as in this study, six months before. Until a comparison is made of scores obtained by children tested at the beginning of grade one and scores obtained by children tested earlier, perhaps one should be skeptical of the conclusion that auditory discrimination improves rapidly during the first school year.

The same skepticism would apply to Wepman's conclusion (1960) that a decrease in error score reflects developmental change alone: no statistically significant change occurred in this study during the grade one period. Perhaps a change in error decrease on Wepman's test might

have occurred between Time 4 in this research and the end of grade one, but the existing data do not support either rapid growth over accomplishment at grade one level or significant developmental change during that time. It is doubtful that significant improvement in auditory discrimination could have been reflected by the Wepman instrument between Time 4 and the end of the school year, since the mean error score at Time 4 was close to a perfect score.

Correlational data from this study do not support those from previous research on auditory discrimination. Correlations between auditory discrimination and reading subtests in this study range from -.018 to -.187 (Table 9, p. 51), and thus conflict with the positive correlations reported by Wepman (1960) and Poling (1968). These correlations would also suggest that auditory discrimination may not be the critical variable for learning to read that Durrell and Murphy (1963) say it is.

Correlations between auditory discrimination and intelligence in grade one have been reported as positive (Thompson, 1963), as negative (Wepman, 1960), and as zero (Durrell and Murphy, 1963). Data from this study support Wepman's findings, with negative correlations at all four testing times and low significant correlations at Times 1 (-.309) and 3 (-.251). It should be kept in mind, however, that variation in the instruments used to report intelligence could be responsible for the difference in correlations. This question is complicated by the fact that

previous experimenters did not report the intelligence test used. The Peabody, as described earlier, is a receptive vocabulary test. Thus it is not surprising that the Peabody-Wepman correlation might be different from correlations between the Wepman test and a Wechsler intelligence test which includes different kinds of intellectual tasks.

As with acuity, there seems to be some developmental improvement in auditory discrimination scores apart from practice effect, but this change was not statistically significant. Secondly, correlational data from this study support Wepman (1960), who reports a positive relationship between auditory discrimination and intelligence.

Auditory memory. As stated earlier, the Stanford-Binet Memory for Sentences subtest was used to test auditory memory skills at the first measuring time; the Betts Sentences were used at Times 2, 3, and 4. The Binet subtest was significantly correlated with one variable at Time 1--the Wepman--a finding that indicates support for Witkin's conclusion (1969) that discrimination is confounded with memory span on some auditory discrimination tests. This relationship is not surprising because one would expect the ability to remember pairs of words to be related to the ability to discriminate between them.

The Betts test scores reflect a slight increase in errors between Times 2 and 3 and a gain or decrease in errors from Time 3 to Time 4. The change over time is not statistically significant; nonetheless, the pattern of

change is interesting. The improvement in memory span between Times 3 and 4 gives some support to Neville's conclusion (1968) that the skill improves during the first year of school (Neville said it "grows" rapidly). The increase in mean error between Times 2 and 3, however, is more difficult to explain, as none of the previous studies report an error increase over time, even a statistically nonsignificant one. Because an hypothesis of practice effect between Times 2 and 3 is contradictory to the trend of memory score, chance factors alone may be responsible.

Poling (1953), Reynolds (1953), and Neville (1968) all report positive correlations between memory span scores and word recognition skills. In part, data from the present study support these researchers. Betts scores at Time 4 show a significant positive correlation with the single consonant subtest of the word recognition skills instrument, but not with the other two: consonant blends and short vowels. The apparent discrepancy may be because the children had not yet been taught those consonant blends and short vowel sounds which are commonly studied after single vowel sounds are taught.

Betts scores also correlated significantly with the comprehension subtest from the Neale reading test. This relationship is understandable in that the Neale subtest scores reflect the child's ability to answer questions about what he has read aloud. This is an ability which depends partly on ability to remember what is read.

In support of Locke's results (1970), auditory memory scores from this study show a significant positive relationship with intelligence, a relationship that became stronger over time. Though the correlations at Times 2, 3, and 4 were not high enough to be of use as predictors (Table 6, p. 46), the data indicate that auditory memory is positively related to intelligence test scores and that the correlations strengthen over time (in this case, the first five months of grade one).

These data give some support for the conclusion that auditory memory span is important in grade one (Patton and Nelly, 1970) and for the suggestion that the skill responds well to training. This should perhaps be emphasized before children learn to read. In addition, the research reported in this paper suggests that such emphasis on training might profitably begin during the three months before children enter school.

In summary, auditory memory data from this research generally support those from other studies, though the growth or developmental trend of this skill did not show the same pattern as did other auditory variables. It would have been less difficult to make conclusions relative to the growth of auditory memory had the Betts instrument been used at all four measuring times.

<u>Pitch discrimination</u>. Like auditory memory, pitch discrimination scores present a less clearcut picture of growth than do the other auditory variables. Data show

that scores from the Seashore subtest showed gains between Times 1 and 2 and from Time 2 to Time 3, and that errors then increased between Times 3 and 4. The fact that five months elapsed between Times 3 and 4 in contrast to three months between the other testing times makes it a bit tenuous to suggest that classroom acoustics had a major effect over the entire time. Still, this interpretation seems plausible in the sense that the acoustics of the children's grade one classroom were likely quite different from those of their pre-school environment.

An alternative explanation is possible for the pitch discrimination scores. Seashore states in his test manual that the pitch subtest is not appropriate to children below grade four. Likewise, Kennedy (1942) did not test children below grade five for pitch discrimination. Somewhat supportive of this position is the Wheeler and Wheeler conclusion (1954) that pitch discrimination does not develop until the end of the child's fourth school year. Both examiners observed evidence that the children had apparent difficulty understanding the concepts in the standardized instructions used with the Seashore test. The fact that the average score was about five out of ten at Time 1 may have been due to the observed tendency of the children arbitrarily to alternate "yes" and "no" answers, rather than to reflect on their ability to discriminate pitch. That there was no apparent practice effect operating on pitch score lends credence to this interpretation, as does the low variance

[illegible]

and slight change in scores over time (Table 5, p. 45). Though the F ratio from the pitch scores over time was significant relative to the selected alpha level, Newman-Keuls analyses between pairs of mean scores were not.

The increase in pitch error scores between Times 3 and 4 were paralleled by the right and left acuity scores at 8000 Hz. As reported in Chapter Four, the lack of significant correlations between discrimination for pitch and these acuity levels maintaining the same pattern dismisses a possibility of relationships between frequency level and pitch discrimination as measured here.

Seashore scores correlated significantly with Wepman scores at Time 1 and Time 4, those times of measurement when Seashore mean error scores were highest. This is a finding which, from these data, is difficult to explain. Also difficult to explain is the significant correlation at Time 4 between Seashore scores and the single consonant subtest of the Roswell-Chall. A possible interpretation of the latter finding is that, by the time children had matured one year and had heard the same instructions four times, Seashore scores at Time 4 were fairly valid; thus the significant relationship with auditory discrimination at Time 4 is likely more valid than at Time 1. Such an interpretation would support Flynn and Byrne's finding (1970) that pitch discrimination and reading scores are related. An interpretation of increased validity in pitch scores at Time 4 also indicates that, if instructions can be made

clear to children, it might be possible to examine children for pitch discrimination before they enter grade three, particularly as such discrimination relates to reading performance. Such a conclusion is contradictory to the Wheeler and Wheeler (1970) position.

If it is true that pitch scores at Times 1, 2, and 3 were affected by instructions which were not clear to the children, it seems difficult to discuss whatever developmental change might have occurred as the result of practice with the task, readiness for the concepts, or both. We will assume that the Time 4 pitch discrimination scores were valid.

Auditory variables and reading scores. With the exception of a few scattered relationships with acuity scores, the only reading subtest scores significantly correlated with the auditory variables in this study were the single consonant subtest from the Roswell-Chall and the comprehension subtest from the Neale test. Even though significant, the correlations were low, ranging from -.251 to .336 (Tables 9 and 10, p. 51).

Table 10 (p. 51) indicates only slight support for those researchers who reported high correlations between acuity scores and reading (Bond, 1935; Betts, 1940; Kennedy, 1942). The four significant relationships between reading subtest scores and acuity scores at three frequencies indicate a weak relationship between pure tone acuity and reading, except perhaps at L8000, where there

were significant correlations with the single consonant subtest of the Roswell-Chall instrument and the accuracy subtest of the Neale instrument.

It is possible that relationships between acuity and reading would strengthen toward the end of the grade one year, the year from which previous researchers have tended to take their measurements. The mid-grade one data from this study, however, conflict with those from earlier studies of hearing and reading.

The data from the present study show no support for researchers who have reported significant relationships between reading and auditory discrimination (Wepman, 1960; Goetzinger, Dirks, and Baer, 1960; Durrell and Murphy, 1962; Thompson, 1963; Poling, 1968). Scores from the Wepman test as obtained in this study were not significantly related to any of the five reading subtest scores. Again, it is possible that the children's reading abilities after five months in grade one were not sufficiently developed to be measured, even with very elementary instruments. Such a conclusion is, however, at variance with results from the single consonant subtest of the Roswell-Chall, which did appear simple for most children, and which was significantly related to pitch discrimination, memory, and two acuity scores. Conceptually, it would appear that the one reading skill most of the children had mastered should have been related to their auditory discrimination ability, but it was not, a result which may be attributed to a possible

floor effect of the Wepman instrument.

On the basis of the present study, then, it seems that research should be conducted to investigate the Wepman test itself. If one were to design research to correlate the reading test scores used in this study with scores from the Wepman and several other tests of speech sound discrimination, it would then be possible to speculate about how much of the lack of relationship between discrimination and reading in this study was due to the validity of the Wepman instrument.

The significant relationship of Betts auditory memory scores at Time 4 to two of the five reading subtest scores (Table 9, p. 51) supports those studies which have reported a positive relationship between auditory memory and reading (Stauffer, 1936; Betts, 1936; Poling, 1953; Reynolds, 1953; Neville, 1968). It appears, then, that auditory memory span, as measured by the Betts test, is a more reliable predictor of reading skills than the other auditory variables in this research. On the basis of the significant correlation between Betts and intelligence scores (which became stronger over time), one could conclude that scores from the Peabody Picture Vocabulary Test may be at least as effective in predicting reading scores as the Betts test scores. If this is true, it might be more efficient to utilize Peabody scores instead of Betts scores, since they could predict auditory memory scores, supply intelligence data, and be more quickly obtained.

Pitch discrimination scores from the Seashore test were significantly related to one reading subtest score, that from the single consonant subtest of the Roswell-Chall. Assuming that pitch scores at Time 4 were more valid than at Time 1, this relationship seems to contradict those researchers who reported a strong relationship between pitch discrimination and reading (Kennedy, 1942; Ewers, 1950; Wheeler and Wheeler, 1954; Flynn and Byrne, 1970) and to support Parker (1970), who reported no relationship between the two. However, if we accept Wheeler and Wheeler's conclusion that pitch discrimination is not developed by the middle of grade one and consider that most earlier pitch studies used children from grades four, five, and six, it is possible to attribute the lack of relationship in this study to underdeveloped pitch discrimination abilities. We would thus predict that the relationship would strengthen as the children grow older. In spite of this alternative interpretation, we support the first interpretation, which assumes that Time 4 pitch scores were valid. Using this explanation, it would be concluded that pitch scores were significantly related only to the single consonant reading subtest because as discussed earlier the children, at that point in time, had studied only single sounds. In other words, the pitch data from this research do not necessarily contradict those from earlier studies, as it is possible that the relationships would strengthen when the children became more proficient in reading skills. At the end of

grade one, then, the Seashore test might well show more significant relationships with various reading tasks.

Related results. Multiple t-tests were used to determine that, except at two frequencies, there was no significant difference at Time 4 between the children who had been tested three times previously on the audiometer and those who had not. The purpose of the audiometric control group, then, was to provide some means for examining what effect learning to use the audiometer might have had on the final audiometric scores. Though differences between the two groups were not statistically significant (Table 11, p. 52), there was a consistent trend for the control group to show more decibel loss than the experimental group, a fact which likely would have been detected as significant by a more powerful statistical test. The difference, however, can be explained by the difference in testing environment. The children who made up the original sample were tested in a soundproof environment, but the controls were tested in a quiet room in the elementary school where they were students. Though audiometric testing was stopped when the inevitable school noise occurred (recess, bells, groups walking through the hall), there was still enough extraneous noise to produce the differences shown in Table 11 (p. 52).

I.Q. scores. Significant relationships between I.Q. scores on the Peabody test and other auditory variables have been discussed in the preceding sections of this chapter.

[illegible]

The intelligence scores themselves, however, are worthy of extra comment. As reported in Table 12 (p. 53), intelligence scores increased significantly over time until school began. Thereafter they decreased slightly. The discussion of practice effect in the acuity section of this chapter would certainly seem to apply to intelligence scores, as the significant change, from the Newman-Keuls analysis, occurred between Time 1 and the other testing times. The most important implication of this finding would seem to be for the common practice of administering group intelligence tests to beginning school children, many of whom have not been tested before. If the same practice effect is found with the group intelligence tests, we must be extremely careful with our interpretations of a child's first test score, or we should not administer the tests until the children rehearse for the same type of task. Alternate forms of a group I.Q. test would accomplish this goal; that is, we could administer Form A of a given test to beginning school children, Form B several weeks later, and discard the lower set of scores if they are statistically different. Such a procedure would prevent a child from being followed through school by an inaccurately low intelligence record.

Differences between examiners. As reported in Chapter 4, the only significant difference between results of the two examiners who tested the children in this study at Times 2 and 4 was with acuity scores at R500 and R4000

at Time 2 and with the Betts test scores at Time 4. In general, the scores obtained seemed to be independent of the examiner. It should be pointed out that the two examiners were similar in philosophy about testing children and that they observed each other testing several children.

Medical examination. The purpose of the medical examination of the children's ears, noses, and throats was to determine if the children were organically normal. A negative diagnosis would preclude an interpretation of acuity score change due to abnormal organic conditions such as ear infection or wax occlusion. Both physicians, on the basis of the findings reported in Table 13 (pp. 55-56), pronounced the children normal as a group.

Chronological age. As Table 14 (p. 56) shows, the Wepman test scores were significantly related to chronological age at Times 1 and 2; and the Betts scores were significantly related at Times 2, 3, and 4. These findings suggest that performance on both instruments is related to and perhaps dependent upon the chronological age of the child at different points in time. In the period between six months and three months prior to grade one, age and auditory discrimination ability are significantly related, a relationship which does not persist in the formal school period. When the children were in the older range represented by the sample in this research, Betts scores, on the other hand, are significantly related to age.

Limitations

In addition to limitations mentioned in the discussion of results from the study, there are several weaknesses relative to this research. First, to satisfy Hilton and Patrick's (1969) criteria for controlling retest effect or the effect of practice on children's scores, a large enough sample should have been selected at random at the outset so that a subsample could have been assigned at random as a control group to be tested at Time 4 only. This becomes especially important in view of the strong apparent practice effect discussed earlier. Though this study did include a control for audiometric data, the control group was selected at random from a school within one of the areas from which the original sample was chosen.

Audiometric testing of controls was done with the same audiometer in a quiet room in the school rather than in the soundproof booth on the university campus. This was done because it was not possible to bring the children to the soundproof facility. There was no significant difference between groups, except at one frequency in one ear.

Ideally--to make the generalization that the children were normal at all testing times--the medical examination should have been performed at each time. It was pragmatically difficult to secure the valuable time of the cooperating doctors for the examinations more than once. Also, the medical examination meant that many parents had to make two trips for testing at Time 4--one for the medical and one for

the audiometric testing. This researcher did not feel she could ask parents to make two trips at each testing time without increasing the probability of dropout from the study.

A limitation related to the Betts sentences used to measure auditory memory in the study is that their administration was not standardized. While piloting the Betts test prior to Time 2, the examiner found that children did not respond when the sentences were tape-recorded, but seemed to require watching the speaker as well as hearing the words uttered. Administration could have been standardized using video tape, but the directions for the test might have become too complex. The size of the soundproof booth prohibited the use of video equipment.

One general limitation of the instruments used in this study may have come from the basis on which they were selected. In other words, they were selected on the basis of brevity with some possible sacrifice of comprehensiveness of measurement. This is particularly true of the reading instruments. As indicated earlier, however, it was felt that discouraging dropout from the study might depend upon the length and quality of the children's experience at each time, and the assumption was made that brief instruments would be preferable.

Implications

In addition to the suggestions for future study made through the past two sections of this chapter, this researcher makes several more. First, growth differences in auditory traits, such as those between Time 1 and Time 2, should be pursued to determine whether the increase was due to a learning effect or to an actual growth spurt. If results from such studies show that practice effect was responsible, then perhaps we might employ practice before children start school as a means of increasing their scores. Certainly this would indicate that perhaps we should test children twice to obtain a set of auditory scores which may be more consistent with their actual performance over time. If we can support the presence of a practice effect, the importance of rejecting a test-naive child's initial set of scores is obvious. The possibility that certain kinds of intelligence measures might be affected suggests that we take a good look at other measures, such as the placement and group I.Q. tests which we use with children when they enter grade one.

So that findings might be generalized outside the actual time periods over which children are observed, a random effects model might be used instead of the fixed model employed in this study (Kirk, 1968, p. 242). With a random effects model the times for testing are chosen at random; thus results apply to a broader span of time than those with fixed times as in this research.

Second, it would seem appropriate for educators to begin to inspect the degree to which the auditory instruments they use correspond to prevailing definitions of auditory perception. As Witkin (1969) points out, there has been little application of auditory theory to educational settings. It may be, for example, that if the Wepman test confounds auditory memory with auditory discrimination, as Goetzinger, Dirks, and Baer (1960) and Blank (1968) suggest, then relationships between the Wepman test and school performance, such as that in reading, may be cloudy simply because the auditory measure does not test discrete skills. This situation is analagous to reading research, where it has been recognized that reading is an extremely complex combination of skills which must be analyzed one by one if we are to describe the process accurately.

This researcher recommends further research which would investigate the relationship between auditory tests, such as those used in this study, and measures that have been built around auditory perceptual definitions. Such a test has been developed by Sabatino (1969) who states:

> The development of psychoeducational instruments to measure auditory perceptual function in children has progressed slowly because of the limited theoretical understanding of this area of human behavior. However, auditory perception is used as a prime means of teaching (p. 730).

Sabatino isolated four areas of auditory perception, around which he built his instrument: auditory recognition, of

sounds and of words; auditory retention, of digits and speech; auditory integration, or the duplicating of rhythm patterns; and auditory comprehension, or the ability of the child to answer yes or no questions based on a story he hears. The test was constructed so that controlled levels of "classroom noise (p. 732)" can be introduced during the test as a means of measuring the level of distraction. Sabatino did not correlate his test, the TAP (Test of Auditory Perception), with established instruments such as the Wepman test, even though he discusses these measures as they relate to the development of his own. It would seem an appropriate step to re-examine educational auditory instruments as they relate to new perceptual tests, with an eye to developing better instruments. Witkin's skills (1969) might also serve as a suitable base for building new instruments to match an auditory theory. These instruments should be correlated with established instruments and with school performance.

If the emphasis upon the worthiness of instruments in this final section appears inappropriately strong, it is because it is very difficult to determine whether our tests are indeed measuring skills or whether the test scores reflect information about the test itself rather than information about the skill. Certainly there have been efforts to test the validity of auditory instruments in education, but the standard tests such as Wepman's and Betts'--upon which so much data from the past decade rest--

were developed many years ago when definitions of auditory perception were less sophisticated. It may be that our "old standards" can bear up under the strain of a new theoretical light or that testing discrete skills is neither desirable nor possible; but such suppositions should not delay the inquiry. Studies such as the one reported here can provide useful information concerning the importance of certain auditory skills to the child entering school. If we would do best for him, we must push our inquiry toward congruence with a responsible definition or theory of auditory perception. For, as Kaplan (1964) attests:

> A hypothesis may be as much confirmed by fitting it into a theory as by fitting it to the facts. For it then enjoys the support provided by the evidence for all the other hypotheses of that theory . . . Theory, therefore, functions throughout inquiry, and . . . has a greater responsibility than that of an accessory after the fact: it guides the search for data, and for laws encompassing them (p. 302).

Researchers in auditory perception can provide us with models, theories, and instruments which allow us both to test the traditional instruments against a perceptual model and where necessary to develop new instruments. Perhaps comparing traditional educational tests with auditory perceptual models will cause us to develop new instruments, or even to demand new theories. If we are concerned with finding tools that help the child in school to perform at the highest level possible for him, we cannot afford to cease or to retard the process of evaluating constantly our diagnostic instruments in the light of recent theoretical inquiry.

Bibliography

Bach, M. J., & Underwood, B. J. Developmental changes in memory attributes. _Journal of Educational Psychology_, 1970, _61_, 292-296.

Betts, E. A. _Ready to read tests_. E. A. Betts, Keystone View Company, c. 1934-1938.

Betts, E. A. Reading problems at the intermediate-grade level. _Elementary School Journal_, 1940, _40_, 737-746.

Blank, M. Cognitive processes in auditory discrimination in normal and retarded readers. _Child Development_, 1968, _39_, 1091-1102.

Bond, G. L. The Auditory and speech characteristics of poor readers. _Teachers College Contribution to Education_, 1935, No. 657.

Broadbent, D. E. Attention and the perception of speech. _Scientific American_, 1962, _143_(3), 143-151.

Buros, O. K. (Ed.) _The sixth mental measurements yearbook_. New Jersey: Gryphon Press, 1965.

Chall, J. S. The Roswell-Chall diagnostic test of word analysis skills. _Reading Teacher_, 1958, _11_, 179-183.

Comprehensive Plan for Hearing Impaired Children in Illinois, Illinois Commission on Children, 1968.

Denes, P. B., & Pinson, E. N. _The speech chain: the physics and biology of spoken language._ New York: Bell Telephone Laboratories, 1963.

Doehring, D. G. Temporal sequence effects in auditory oddity discrimination. _Perception and Psychophysics_, 1969, _6_, 65-68.

Dunn, L. M. _Peabody picture vocabulary test_. Minneapolis: American Guidance Services, 1965.

Durrell, D. D., & Murphy, H. A. The auditory discrimination factor in reading readiness and reading disability. _Education_, 1963, _73_, 556-560.

Dykstra, R. Auditory discrimination abilities and reading achievement. _Reading Research Quarterly_, 1966, _1_(3), 5-35.

Eagles, E. Hearing levels in children and implications for identification audiometry. Journal of Speech and Hearing Disorders, 1961, Supplement 9, 52-62.

Ewers, D. W. F. Relations between auditory abilities and reading abilities: a problem in psychometrics. Journal of Experimental Education, March, 1950, 18, 239-262.

Flynn, P. T., & Byrne, M. C. Relationships between reading and selected auditory abilities of third-grade children. Journal of Speech and Hearing Research, 1970, 13, 731-740.

Frisina, R. Measurement of hearing in children. In J. Jerger (Ed.), Modern development in audiology. New York: Academic Press, 1963.

Goetzinger, C.P., Dirks, D.D., & Baer, C. J. Auditory discrimination and visual perception in good and poor readers. Annals of Otology, Rhinology, and Laryngology, 1960, 69, 121-136.

Heckelman, R. G. Is reading an instantaneous memory process? Academic Therapy Quarterly, 1968, 3, 231-232.

Henry, S. Children's audiograms in relation to reading attainment. Journal of Genetic Psychology, 1947, 13, 211-231.

Hilton, T. L., & Patrick, C. Cross-sectional versus longitudinal data: an empirical comparison of mean differences in academic growth. Journal of Educational Measurement, 1970, 7, 15-24.

Hipskind, N. M. Effects of experimenter bias upon pure-tone and speech audiometric test results. Unpublished doctoral dissertation, University of Illinois. (Dissertation Abstracts, 30B:426).

Huffman, L., & McReynolds, L. Auditory sequence learning in children. Journal of Speech and Hearing Research, 1968, 11, 169-178.

Johnson, M. S. Factors related to disability in reading. Journal of Experimental Education, 1957, 26, 1-26.

Kaplan, A. The conduct of inquiry: methodology for behavioral science. San Francisco: Chandler Publishing Co., 1964.

Karlin, J. E. The factorial isolation of the primary auditory abilities. Unpublished doctoral dissertation, University of Chicago, 1942.

Kennedy, H. A study of children's learning as it relates to reading. Journal of Experimental Education, 1942, 10, 238-251.

Kirk, R. E. Experimental design: procedures for the behavioral sciences. Belmont, California: Brooks/Cole, 1968.

Kupfer, G. Alberta, Executive Council, Community Opportunity Assessment. Edmonton: Gov't. of Alberta, 1967.

Locke, J. L. Discriminative learning in children's acquisition of phonology. Journal of Speech and Hearing Research, 1968, 11, 428-434.

Locke, J. L. Short-term auditory memory, oral perception, and experimental sound learning. Journal of Speech and Hearing Research, 1969, 12, 185-192.

Lowell, E. L. Evaluation of pure tone audiometry with preschool age children. Journal of Speech and Hearing Disorders, 1956, 21, 292-302.

Moed, G., Wight, B. W., & James, P. Intertest correlations of the Wechsler Intelligence Scale for Children and two picture vocabulary tests. Educational and Psychological Measurement, 1963, 23, 359-363.

Monsees, E. K. Temporal sequence and expressive language disorders. Exceptional Children, 1968, 35, 141-148.

Mykelbust, H. R. Auditory disorders in children: a manual for differential diagnosis. New York: Grune & Stratton, 1954.

Neale, M. D. Neale Analysis of Reading Abilities. London: Macmillan, 1958.

Neville, M. H. Effect of reading method on the development of auditory memory. Reading Teacher, 1968, 22, 30-35.

Parker, D. H. H. Musical perception and backwardness in reading. Educational Research, 1970, 12, 244-246.

Patton, W. F., & Nelly, V. C. Effects of training procedures on recall of auditory sequences by children. Perceptual and Motor Skills, 1970, 30, 691-697.

Poling, D. L. Auditory deficiencies of poor readers. _Supplementary Educational Monographs_, 1958, No. 87.

Poling, D. The relationship of auditory discrimination to achievement. Unpublished doctoral dissertation, University of Chicago, 1968.

Price, L., & Falck, V. Bekesy audiometry with children. _Journal of Speech and Hearing Disorders_, 1963, _6_, 129-133.

Raymond, D. M. The performance of reading achievers on memory span and associative learning tests. _Journal of Educational Research_, 1955, _48_, 455-465.

Read, C. Pre-school children's knowledge of English phonology. _Harvard Educational Review_, 1971, _41_, 1-34.

Reid, R. Auditory aspects of reading readiness. Unpublished M.A. thesis, University of Alberta, 1962.

Reynolds, M. C. A study of the relationships between auditory characteristics and specific silent reading abilities. _Journal of Educational Research_, 1953, _48_, 439-449.

Rose, F. C. The occurrence of short auditory memory span among school of children referred for diagnosis of reading difficulties. _Journal of Educational Research_, 1958, _51_, 459-464.

Roswell, F. G., & Chall, J. S. _Roswell-Chall diagnostic reading test of word analysis skills_, New York: Essay Press, 1959.

Rupp, J. C. C. _Helping the child to cope with the school_. Walters-Noordhaff m.v. Groningen, 1969.

Sabatino, D. A. The construction and assessment of an experimental test of auditory perception. _Exceptional Children_, 1969, _35_, 729-738.

Saunders, M. J. The short auditory span disability. _Childhood Education_, 1931, _8_, 59-65.

Seashore, C. E. _Tests of musical talent_. New York: The Psychological Corporation, 1950.

Siegenthaler, B., Pearson, J., & Lezak, R. A speech reception threshold test for children. _Journal of Speech and Hearing Disorders_, 1954, _19_, 360-366.

Stauffer, R. G. Certain psychological manifestations of retarded readers. Journal of Educational Research, 1948, 41, 436-452.

Stevens, S. S. (Ed.). Handbook of experimental psychology. New York: Wiley, 1951.

Templin, M. C. Certain language skills in children: their development and interrelationships. Minneapolis: University of Minnesota Press, 1957.

Thompson, B. B. A longitudinal study of auditory discrimination. Journal of Educational Research, 1963, 56, 376-378.

Warren, R. M., & Warren, R. P. Auditory illusions and confusions. Scientific American, 1970, 223(6), 30-36.

Wepman, J. M. Auditory discrimination test. 950 East 59th St., Chicago, 1958.

Wepman, J. M. Auditory discrimination, speech, and reading. Elementary School Journal, 1960, 325-334.

Wheeler, L. R., & Wheeler, V. D. A study of the relationship of auditory discrimination to silent reading abilities. Journal of Educational Research, 1954, 48, 103-113.

Wiener, M., & Cromer, W. Reading and reading difficulty: a conceptual analysis. Harvard Educational Review, 1967, 37, 620-642.

Winitz, H. Sex differences in language of kindergarten children. American Speech and Hearing Association, 1, 1959, 86.

Witkin, B. R. Auditory perception: implications for language development. Journal of Research and Development in Education, 1969, 3, 53-71.

Zigmond, N. K., & Cicci, R. Auditory learning. San Rafael: Dimensions Publishing Company, 1968.

Appendix A

Sampling Areas - Edmonton, Alberta

Kupfer	Polling Division
#29	#161, 166, 171
#37	#85, 86, 87, 88, 89
#44	#225, 226, 227, 228

Appendix B

Significant Analysis of Variance Results for all Variables

Anova for L250

Source	MS	DF	F	
Between people	92.708	48		
Within people	54.549	147		Conservative prob. =
Treatments	415.092	3	8.824	.0046
Residual	47.037	144		
Total		195		

Anova for R250

Source				
Between people	58.099	48		
Within people	37.882	147	6.607	Conservative prob. =
Treatments	224.617	3		.0133
Residual	33.992	144		
Total		195		

Anova for L500

Source				
Between people	86.745	48		
Within people	50.850	147	9.469	Conservative prob. =
Treatments	410.544	3		.0034
Residual	43.356	144		
Total		195		

Anova for R500

Source				
Between people	59.587	48		
Within people	47.619	147	12.865	Conservative prob. =
Treatments	493.197	3		.0007
Residual	38.336	144		
Total		195		

Anova for L1000

Source				
Between people	70.785	48		
Within people	37.159	147	8.371	Conservative prob. =
Treatments	270.408	3		.0057
Residual	32.300	144		
Total		195		

Appendix (con't)

Anova for R1000

Source	MS	DF	F	
Between people	67.883	48		
Within people	45.323	147	11.788	Conservative prob. = .0012
Treatments	437.585	3		
Residual	37.150	144		
Total		195		

Anova for L2000

Source				
Between people	65.502	48		
Within people	32.355	147	10.011	Conservative prob. = .0027
Treatments	273.596	3		
Residual	27.329	144		
Total		195		

Anova for R2000

Source				
Between people	63.929	48		
Within people	28.316	147	9.559	Conservative prob. = .0033
Treatments	230.442	3		
Residual	24.105	144		
Total		195		

Anova for L8000

Source				
Between people	157.764	48		
Within people	69.642	147	4.136	Conservative prob. = .0475
Treatments	270.748	3		
Residual	65.453	195		

Anova for R8000

Source				
Between people	165.205	48		
Within people	55.016	147	7.137	Conservative prob. = .0102
Treatments	348.979	3		
Residual	48.892	144		
Total		195		

Appendix (con't)

Anova for Wepman

Source	MS	DF	F	
Between people	80.520	48		
Within people	30.052	147	19.344	Conservative prob. = .00006
Treatments	422.997	3		
Residual	21.866	144		
Total		195		

Anova for Betts

Source				
Between people	63.843	48		
Within people	7.163	98	9.430	Conservative prob. = .0035
Treatments	57.638	2		
Residual	6.111	146		
Total		195		

Anova for Seashore

Source				
Between people	19.361	48		
Within people	5.899	147	4.878	Conservative prob. = .0319
Treatments	26.671	3		
Residual	5.466	144		
Total		195		

Anova for I.Q.

Source				
Between people	792.395	48		
Within people	100.340	147	4.530	Conservative prob. = .0384
Treatments	424.000	3		
Residual		195		

Appendix C

Pearson r's for Times 1, 2, 3 & 4

Time 1

	1 IQ	2 L250	3 L500	4 L1000	5 L2000	6 L4000
1	1.000000	-.066208	-.071756	*-.236074	-.052861	-.103064
2		1.000000	* .635720	* .616461	.174686	* .443262
3			1.000000	* .763065	* .388966	* .529025
4				1.000000	* .263341	* .499783
5					1.000000	* .589670
6						1.000000
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]				
[illegible]					

Time 1 (con't)

	7 L8000	8 R250	9 R500	10 R1000	11 R2000	12 R4000
1	-.152679	-.076544	.020027	.112722	-.069565	-.070119
2	* .288387	* .435487	* .381482	.177299	.166512	* .270737
3	* .262758	* .308762	* .418009	.107296	* .261224	.133572
4	* .331970	* .287558	* .396270	.096524	.204788	* .261693
5	* .253803	.199808	* .269868	.150530	* .467816	.175179
6	* .276939	* .317562	* .338723	.128613	* .400961	* .335330
7	1.000000	* .349797	* .265018	.147777	* .342380	* .238635
8		1.000000	* .638630	* .562521	* .509295	* .450894
9			1.000000	* .597968	* .528327	* .589180
10				1.000000	* .373245	* .501990
11					1.000000	* .476880
12						1.000000
13						
14						
15						
16						
17						

Time 1 (con't)

	13 R8000	14 WEPMAN	15 SEASHORE	16 BETTS	17 C.A.
1	.090850	*-.309313	-.109695	.141012	.067735
2	* .263408	.145814	.063320	.157861	-.184713
3	.051988	.015195	-.026548	.073564	-.075821
4	.110195	* .283069	.130262	.169499	-.120749
5	* .270868	-.020716	.019478	-.121881	-.155373
6	* .234746	-.072415	* .336253	-.075565	-.114302
7	* .454110	.022501	-.025648	-.062467	-.055252
8	* .367556	.043697	-.077449	.046231	.0
9	* .347258	-.028114	.063720	.160297	-.028217
10	.217253	-.047703	-.012357	.129642	.064442
11	* .483757	-.017734	.023523	-.168739	-.011881
12	* .544602	.103678	.095487	.079039	-.110446
13	1.000000	-.067509	.099666	-.155764	-.104800
14		1.000000	* .305209	-.226564	-.239978
15			1.000000	.175296	-.022584
16				1.000000	.134812
17					1.000000

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]			
	[illegible]				

Appendix C

Pearson r's for Times 1, 2, 3 & 4

Time 2

	1 IQ	2 L250	3 L500	4 L1000	5 L2000	6 L4000
1	1.000000	*-.460053	*-.427932	*-.413269	-.126794	-.210708
2		1.000000	* .795497	* .746264	* .388926	* .526449
3			1.000000	* .768011	* .372938	* .404471
4				1.000000	* .362997	* .461766
5					1.000000	* .609652
6						1.000000
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]				
[illegible]					

Time 2 (con't)

	7 L8000	8 R250	9 R500	10 R1000	11 R2000	12 R4000
1	-.081025	*-.409948	*-.396332	*-.307019	-.108089	-.085592
2	* .284509	* .413987	* .444125	.220523	-.026726	.168519
3	* .350033	* .305939	* .455707	* .329152	-.055038	.136079
4	* .250705	* .314583	* .501354	* .375781	.107251	.194019
5	* .389926	.195520	* .319868	.148558	* .258570	* .373819
6	* .294064	* .268199	* .353131	* .302782	* .264239	* .472226
7	1.000000	* .243850	* .359736	.134347	.161108	* .368807
8		1.000000	* .720804	* .476721	.218899	* .454719
9			1.000000	* .618479	* .344318	* .631548
10				1.000000	* .384610	* .534779
11					1.000000	* .544936
12						1.000000
13						
14						
15						
16						
17						

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]				
[illegible]					

Time 2 (con't)

	13 R8000	14 WEPMAN	15 SEASHORE	16 BETTS	17 C.A.
1	.041349	-.134741	-.072329	* .279815	-.042798
2	-.125271	-.064655	.189396	-.015958	-.032503
3	-.069677	-.084967	.161965	-.047608	-.074252
4	-.019565	-.198517	.077437	.112295	-.153916
5	* .252980	.074611	.129532	-.017986	-.140824
6	.197439	-.209498	-.012640	.103981	-.145311
7	* .571990	.012120	-.009193	* .249391	*-.293170
8	* .277724	.115290	.021334	-.130913	.186252
9	* .398675	.021553	-.006332	-.122914	.035272
10	* .341508	-.038887	.051197	-.130262	.167190
11	* .396584	.087271	.012354	.049187	-.132139
12	* .583512	.070551	-.179972	-.066695	-.093588
13	1.000000	-.022125	-.174364	.183744	*-.328226
14		1.000000	.092701	*-.485375	* .327302
15			1.000000	-.159718	* .335070
16				1.000000	*-.617723
17					1.000000

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]			[illegible]
[illegible]	[illegible]				[illegible]
[illegible]					[illegible]

Appendix C

Pearson r's for Times 1, 2, 3 & 4

Time 3

	1 IQ	2 L250	3 L500	4 L1000	5 L2000	6 L4000
1	1.000000	-.004760	-.105346	-.098977	-.073098	-.049495
2		1.000000	* .668850	* .316398	* .236479	* .326602
3			1.000000	* .537258	* .237883	* .318041
4				1.000000	.145395	* .251375
5					1.000000	* .361376
6						1.000000
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]				
[illegible]					

Time 3 (con't)

	7 L8000	8 R250	9 R500	10 R1000	11 R2000	12 R4000
1	.102445	-.158694	-.136586	-.040411	*-.325188	-.065382
2	* .351462	* .387711	* .485258	* .240230	* .284841	.111507
3	* .246072	* .447510	* .566681	* .397205	* .252250	.105102
4	* .295375	* .265496	* .302532	* .518868	.228154	.168394
5	* .292985	.102327	-.031683	.119976	* .455902	.099466
6	* .341295	.144444	.143542	* .398197	* .326166	* .542157
7	1.000000	.041407	.098525	.219922	.127338	* .258475
8		1.000000	* .711805	* .430895	* .373888	.178983
9			1.000000	* .523734	.116133	.199968
10				1.000000	* .400226	* .396006
11					1.000000	* .302199
12						1.000000
13						
14						
15						
16						
17						

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]			[illegible]
[illegible]	[illegible]	[illegible]				[illegible]
[illegible]	[illegible]					[illegible]
[illegible]						[illegible]
						[illegible]
						[illegible]
						[illegible]
						[illegible]
						[illegible]
						[illegible]

Time 3 (con't)

	13 R8000	14 WEPMAN	15 SEASHORE	16 BETTS	17 C.A.
1	-.067042	*-.251890	-.162811	* .415205	-.218602
2	.022171	-.036014	* .242492	-.049574	.142780
3	.181318	.211692	* .407467	-.234175	.037186
4	.140843	.209615	* .243230	-.149593	.065240
5	.198227	.123717	.049480	-.013165	-.052975
6*	.406607	* .381903	.128846	-.129372	-.108818
7*	.333113	.019560	-.006042	.042870	-.041114
8	-.021445	* .292791	* .324397	-.158615	.152451
9	.192129	.131285	* .287313	-.095469	.090903
10*	.350357	* .446002	.162881	-.053905	.112495
11	.221100	.177003	.138322	-.141910	.187320
12*	.442848	.135048	.036041	-.138981	.041231
13	1.000000	.127969	-.120738	*-.267719	.089632
14		1.000000	.107210	*-.239922	.013961
15			1.000000	-.159533	-.110473
16				1.000000	*-.501056
17					1.000000

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]			[illegible]
[illegible]	[illegible]				[illegible]
[illegible]					[illegible]

Appendix C

Pearson r's for Times 1, 2, 3 & 4

Time 4

	1 IQ	2 L250	3 L500	4 L1000	5 L2000	6 L4000
1	1.000000	-.182000	-.172843	-.098711	-.164660	-.226916
2		1.000000	* .583746	* .419895	* .414295	* .381542
3			1,000000	* .735694	.431650	* .477586
4				1.000000	* .419389	* .649206
5					1.000000	* .674963
6						1.000000
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						

Time 4 (con't)

	7 L8000	8 R250	9 R500	10 R1000	11 R2000	12 R4000
1	-.080134	-.122466	-.119514	-.064251	.115422	.018522
2	* .415030	* .693533	* .333364	.144902	.176044	.134771
3	* .372877	* .523004	* .502750	* .267638	* .239335	* .241960
4	* .244748	* .305245	* .371642	* .454185	* .361655	* .325601
5	* .357989	* .286558	* .294714	* .255373	* .361510	* .410443
6	.226220	.215821	.209726	* .352773	.193239	* .446029
7	1.000000	* .340400	* .248832	.049486	* .278295	* .339917
8		1.000000	* .515073	* .265894	.222314	.160157
9			1.000000	* .378993	.219382	* .270933
10				1.000000	* .469406	* .473418
11					1.000000	* .507819
12						1.000000
13						
14						
15						
16						
17						

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]				
[illegible]					

Time 4 (con't)

	13 R8000	14 WEPMAN	15 SEASHORE	16 BETTS	17 C.A.
1	.16034	-.093531	.025341	* .417189	-.154298
2	* .237067	.123896	.088181	.036529	-.032711
3	.166493	.155137	.116849	-.065504	-.105206
4	.143321	.038169	.145849	-.049596	-.117360
5	* .280016	* .282780	.148332	-.225179	-.060076
6	.135176	.120106	.047605	*-.276246	-.006051
7	* .491523	.098115	.178207	.014898	*-.295077
8	* .469163	.227566	.053110	.067913	-.113847
9	* .296829	* .324477	.111644	-.036360	-.038114
10	* .280240	.209357	-.004183	.030292	-.076663
11	* .346608	.163456	.097457	* .317344	*-.381658
12	* .476114	* .358952	.055175	-.081281	-.150673
13	1.000000	* .258170	.156399	.062092	-.150673
14		1.000000	* .341231	* .304610	.011884
15			1.000000	-.152538	-.053367
16				1.000000	*-.587909
17					1.000000

[illegible]

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
	[illegible]	[illegible]	[illegible]			[illegible]
	[illegible]	[illegible]				[illegible]
	[illegible]					[illegible]

Appendix D

INSTRUMENTS

BETTS SENTENCES

I am going to tell you something. After I have finished, you say it. First, two examples:

I have a kitten.
Our puppy ran away.

1. My kitten likes milk.
2. Mother will be here soon.
3. Jack Frost comes when I am fast asleep.
4. I rode the pony far into the woods.
5. The hen opened the bag and ran away.
6. My brother did not know which way to go.
7. When my rabbit gets loose, he is hard to catch.
8. A rabbit chased the puppy all the way home.
9. We like to wade in the water when it is not too cold.
10. The small white chick had no mother.
11. When the kite was high in the sky, the string broke.
12. The little pine had long green needles.
13. The sun was shining, but the rain kept falling.
14. The big brown bear ate honey three times that day.
15. The sly fox had a large bushy tail.
16. We had dogs, kittens, and rabbits in our circus.
17. The little children saw the pretty rainbow in the sky.
18. In winter, we slide down the hill on our sleds.
19. The big eyes of the owl were bright and shining.
20. The postman brings us letters or packages almost every day.
21. A goat ate all the fresh green leaves on the tree.
22. He was a tall lean man with a long gray beard.
23. When winter comes, the animals grow heavy coats of fur to keep them warm.
24. The nice little puppy played with the white furry kitten all day long.
25. The carpenter had a heavy hammer, a sharp saw, and a long ladder.

Roswell-Chall Diagnostic Reading Test

I.

s	p	m	c	h	b
r	n	k	j	w	z
d	g	l	f	v y	t
ch	fl	the	st	tr	
cr	sh	wh	str	scr	

II.

let	rim	nap	dot	hut
sip	mad	tub	beg	mob

He took a sip of milk from the top of the jug.

Sam let him take a nap on the cot in the hut.

i o a u e

III.

pin	cut	dim	mat	rob
pine	cute	dime	mate	robe

IV.

seek	pail	coast	harm
gain	boil	load	cart
meal	coin	leaf	peel

V.

daytime	overcome	invented
enjoyment	expansion	contribution
departmental	permanently	

Wepman

AUDITORY DISCRIMINATION TEST

FORM I

			X	Y				X	Y
1.	tub	- tug			21.	cat	- cap		
2.	lack	- lack			22.	din	- bin		
3.	web	- wed			23.	lath	- lash		
4.	leg	- led			24.	bum	- bomb		
5.	chap	- chap			25.	clothe	- clove		
6.	gum	- dumb			26.	moon	- noon		
7.	bale	- gale			27.	shack	- sack		
8.	sought	- fought			28.	sheaf	- sheath		
9.	vow	- thou			29.	king	- king		
10.	shake	- shape			30.	badge	- badge		
11.	zest	- zest			31.	pork	- cork		
12.	wretch	- wretch			32.	fie	- thigh		
13.	thread	- shred			33.	shoal	- shawl		
14.	jam	- jam			34.	tall	- tall		
15.	bass	- bath			35.	par	- par		
16.	tin	- pin			36.	pat	- pet		
17.	pat	- pack			37.	muff	- muss		
18.	dim	- din			38.	pose	- pose		
19.	coast	- toast			39.	lease	- leash		
20.	thimble	- symbol			40.	pen	- pin		

Error Score X /30 Y /10

NEALE ANALYSIS OF READING ABILITIES

1. Kitten

A black cat came to my house. She put her kitten by the door. Then she went away. Now I have her baby for a pet.

Questions
1. What came to the little boy's/girl's house?
2. Where did the black cat leave her kitten?
3. What did the black cat do then?
4. What did the little boy/girl do with the kitten?

2. Tom

Tom stopped on his way to school. The milkman's horse had wandered in the fog. The horse and cart blocked the centre of the road. Traffic was coming. There was no time to call the milkman. Quickly Tom led the horse to safety just as the frightened milkman returned.

Questions
1. Where was Tom going?
2. What did he see on the way?
3. What had happened to the horse?
4. What kind of day was it? or What was the weather like?
5. Why was it dangerous for the horse and cart to stay there?
6. Why didn't Tom call the milkman?
7. What did Tom do?
8. How did the milkman feel as he came running back?

3. Circus

The lions' final act was in progress. Jack stood waiting to clear the ring. Tonight the thunder outside the circus tent has made the lions restless. Suddenly Tess, the lion trainer, stumbled. Her whip fell. The youngest lion sprang towards her. Swiftly Jack leaped inside the cage, cracking the whip with great skill. His prompt action enabled Tess to regain control quickly. During that brief adventure, however, Jack had decided upon his future work.

Questions
1. Where did this story take place? or Where was all this happening?
2. Were the lions near the beginning, near the middle or near the end of their act?
3. What was Jack waiting to do?
4. Why were the lions restless?
5. What happened to Tess?
6. What did Jack do?
7. Who finished the act?
8. What did Jack decide after this adventure?

[illegible]